Essays on Market Microstructure and Stock Market Liquidity

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DECLARATION OF AUTHORSHIP

I (Sung Kyu Lim) hereby declare that this thesis and the work presented in it is entirely my own. Where I have consulted the work of others, this is always clearly stated.

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ABSTRACT

Market microstructure is a branch of finance concerned with theoretical, empirical, and experimental research on the security markets. It emerged as a consequence of a variety of frictions (trading frictions and asymmetric information) that caused an inconsistency between actual and expected prices. Despite the theoretical and empirical development in various subfields, such as the role of information in the price discovery process, asymmetric information, control of liquidity, and regulation of alternate trading mechanisms and market structure, there are a number of questions associated with less researched issues in the market microstructure literature. These include the liquidity volatility spillover effect, conflicts associated with multidimensional characteristics of liquidity, and impact of liquidity on various economic indicators.

The aims of this thesis are outlined in Chapter One, while Chapter Two provides a detailed review of the theoretical literature relevant to the study. Chapter Three is the first empirical chapter which investigates liquidity spillover effects between the UK and East Asian markets, such as Japan, Korea, China and Hong Kong, as well as the US. Results show significant spillover effects between both the UK and the US, and the UK and the Asian countries. Chapter Four tests whether the commonality in liquidity is priced in the UK, extracting common factors from different liquidity measures and creating an across-measure which captures as many facets of liquidity as possible, following Korajczyk and Sadka (2008). However, it obtains weaker evidences regarding the pricing of the across-measure compared to the US. Finally, Chapter Five details the empirical study, investigating the effect of the national and global stock market liquidity on macroeconomic variables for the developed and developing Asia-Pacific economies. Results show that some of liquidity variables are able to predict the macroeconomic variables even after controlling for financial variables, but these are not consistent over selected countries. Thus, the study provides clear evidence to show that the liquidity variables have some ability to predict macroeconomic indicators, but this ability is country and variable specific.

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List of Abbreviations

Abbreviation	Meaning
ABS	Absolute bid-ask spread
ABSP	Daily Absolute bid-ask Spread
APSP	Daily Proportional bid-ask spread
ADF	Augmented Dickey Fuller
AM	Amihud Measure
AMEX	American Stock Exchange
AR	Autoregressive
ARCH	Autoregressive Conditional Heteroskedasticity
ARMA	Autoregressive-moving-average Model
B/M	Book-to-market Ratio
CAPM	Capital Asset Pricing Model
CDS	Credit Default Swap
CON	Private Consumption Growth
DEP	Dependent Variables
DY	Dividend Yield
EMH	Efficient Market Hypothesis
E-GARCH	Exponential General Autoregressive Conditional Heteroskedasticity
EXR	Excess Market Returns
FF4	Fama-French Four Factor
FTSE 100	A share index of the 100 companies listed on the London Stock Exchange
FTSE 250	A share index of the 250 companies listed on the London Stock Exchange
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
GARCH-M	Generalized Autoregressive Conditional Heteroskedasticity in Mean

GAM	Global Amihud Measure
$\mathrm{GAM}^{\mathrm{L}}$	Global Amihud Measure for Large Firms
GAM^{S}	Global Amihud Measure for Small Firms
GDP	Gross Domestic Production
G&G	Galariotis and Giouvris
GRO	Global Roll Measure
$\mathrm{GRO}^{\mathrm{L}}$	Global ROLL Measure for Large Firms
$\mathrm{GRO}^{\mathrm{S}}$	Global ROLL Measure for Small Firms
Hang Seng	A market index in Hong Kong
HML	High-minus-low Equity Portfolio
ILLIQ	Illiquidity Measure
INV	Growth in Investment
K&S	Korajczyk and Sadka
KOSPI	Korea Composite Stock Price Index
LCAPM	Liquidity-adjusted Capital Asset Pricing Model
LIQ	Liquidity
LOT	Liquidity Measure by Lesmond, Ogden, and Trzcinka (1999)
MACRO	Macroeconomic Variables
M-GARCH	Multivariate Generalized Autoregressive Conditional Heteroskedasticity
MKT	Value-weighted Market Portfolio
MSE	Mean Squared Errors
NAM	National Amihud Measure
NAM^{L}	National Amihud Measure for Large firms
NAM^{S}	National Amihud Measure for Small firms
NASDAQ	National Association of Securities Dealers Automated Quotations
NIKKEI 225	A stock market index for the Tokyo Stock Exchange
NRO	National ROLL Measure
NRO^{L}	National ROLL Measure for Large firms
NRO^{S}	National ROLL Measure for Small firms

NSH	Outstanding Amount of Stocks
NSO	Naes, Skjeltorp, and Odegaard
NYSE	New York Stock Exchange
P	Portfolio
PCA	Principal Component Analysis
PP test	Phillips-Perron test
PRO	Proportional bid-ask spread
RO	Roll Measure
SD	Standard Deviation
Shen Zhen	A market index for China
SMB	Small-minus-big Market Capitalization
S&P 100	A stock market index of United States stocks maintained by Standard & Poor's including 100 leading U.S stocks
TO	Turnover
UMD	Momentum Portfolio
UN	Growth in Unemployment
VO	Volume

CHAPTER 1: INTRODUCTION

In modern finance, the most important concept in the relevant literature is that of the efficient market hypothesis (EMH). According to Fama (1970), if new information is revealed about a firm, it will be incorporated into the share price rapidly and rationally. Therefore, price changes occur only with new information because the news is defined as random events. However, in the real world, the financial market is more complex because: (i) trades do not arrive simultaneously in the marketplace; and (ii) information is asymmetric. Building on these frictions, two main strands of standard microstructure literature have developed, namely, inventory-based models (Stoll, 1978a; Amihud and Mendelson, 1980; Ho and Stoll, 1981) and information-based models (Glosten and Milgrom, 1985; Kyle, 1985; Easley and O'Hara, 1992). The inventory-based models postulate the primary role of market-makers as liquidity providers and show how the bid-ask spread compensates them for price risk on inventory, while the information-based models focus on asymmetric information among market participants and show how market-makers set the bid-ask spread to compensate for adverse selection costs.

While all the considerable research mentioned above is clearly theoretical, existing empirical literature on price formation and liquidity has attracted great attention, especially for examining the relationship between liquidity and asset returns. Amihud and Mendelson (1986) investigate the influence of liquidity on stock returns on New York Stock Exchange (NYSE) stocks over the period 1961-1980. They use bid-ask spread as a liquidity measure that shows a strong positive relationship with stock returns. Eleswarapu and Reinganum (1993) apply the model of Amihud and Mendelson (1986) to the NYSE using an extended sample from 1961 to 1990. They find that a positive relationship between liquidity and returns exists only in January. Jun, Marathe and Shawky (2003) look into the relationship between returns and liquidity measures such as turnover ratio, trading volume and turnover-volatility ration for 27 emerging markets from 1992 until 1999. They show that stock returns in emerging markets are positively correlated with liquidity measures. In general, these studies demonstrate the existence of a relationship between liquidity and returns using different proxies in order to emphasise the role of liquidity in stock markets. This is an important determinant for companies, investors, regulators and the market itself.

Liquidity is the degree to which an order can be executed within a short period of time at a price close to a security's fundamental value. Conversely, a price that deviates substantially from this consensus value indicates illiquidity. In an illiquid market, buy orders appear to push transaction prices up, and sell orders tend to push it down. More importantly, when the market is in downturn, the deviation is so great that it is not feasible to trade, and the market freezes. In other words, a provision for liquidity is the most crucial issue for the existence of a market. The recent financial crisis in 2007 has drawn considerable attention to the concept of liquidity. Even though it has been long understood that liquidity is an essential element required for the functioning of financial markets, before the crisis not enough attention was paid to studying and understanding the concept of liquidity and the different aspects of it. Therefore, this study concentrates on less researched issues in the market microstructure literature such as the liquidity-volatility spillover effect, conflicts associated with multidimensional characteristics of liquidity, and the impact of liquidity on various economic indicators.

Beyond the theoretical developments and empirical studies (the impact of liquidity on returns), researchers have discovered the co-movement of liquidity (commonality). Such commonality in liquidity forms a systemic component of individual security's risk (Chordia, Roll and Subrahmanyam, 2000; Pastor and Stambaugh. 2003; Acharya and Pedersen, 2005), which cannot be diversified away, and hence is particularly important to understand for effective risk management and asset pricing. Commonality in liquidity can also drive liquidity spillovers, both during good times (when market liquidity increases) and during bad times (sudden liquidity dry-ups in times of crisis) due to correlated institutional risk averse investors and enhanced financial linkages of international markets. Especially during bad times, liquidity is the most crucial feature to ensure financial market stability. However, academic research on spillover effects associated with liquidity is rather limited. The first attempt to test the dependence of liquidity between the US equity market and the bond market has been made by Chordia, Sarka and Subrahmanyam (2005). They use a vector autoregressive model and find that return volatility shocks predict an increase in bond liquidity. Also, Chordia, Sarka and Subrahmanyam (2006) emphasise that shocks to liquidity in one market have a spillover effect across different sectors of stock markets. They show that liquidity innovations in either the large or small cap sector are informative in predicting liquidity. All these and other studies (presented in Chapter Three in more detail) in the financial literature are not focused on the liquidity-volatility spillover effect at cross-country level. Thus, chapter three examines international stock markets in terms of: (i) the aggregate stock market liquidity and level of volatility; and (ii) the existence of the liquidity-volatility spillover effect.

Chapter four of the thesis is concerned with examining the multidimensional aspect of liquidity proxies and commonality in liquidity. Empirical findings show that there is a positive relationship between bid-ask spread and returns: Amihud and Mendelson (1986) (New York Stock Exchange from 1961 to 1980), and Jun, Marathe, and Shawky (2003) (27 emerging markets from 1992 to 1999). Other studies show a negative relationship between stock returns and liquidity. These include Datar, Narayan, and Radcliffe (1998) (for NYSE from 1962 to 1991) and Dey (2005) (48 stock exchanges between 1995 and 2001). The debate about empirical findings could stem from various characteristics of liquidity proxy and country-specific market identity. Thus, for an empirical study related to the impact of liquidity on stock returns, it is crucial to analyse markets using a type of liquidity measure that captures as many facets of liquidity as possible. This is because various liquidity proxies do not behave in a uniform manner in a market, and this is very noticeable especially when international markets are examined. Brown et al. (2008) argue that the main determinants of commonality in liquidity are different for each market because each of the markets they look into has different trading mechanisms, and the traders' behaviour is different. Moreover, Chai, Faff, and Gharghori (2010) emphasise the multidimensional characteristics of liquidity by looking at the relationships between six liquidity proxies and between the liquidity proxies and stock characteristics in the Australian stock market. Therefore, this paper presents the different behaviour of various liquidity proxies over time and investigates commonality in liquidity with an alternative liquidity proxy that could capture as many facets as possible.

Chapter five is about the impact of liquidity on economic conditions. There is a huge amount of theoretical literature about the link between stock markets and the economy. Most of the empirical studies give evidence of existing relationships between financial development and economic growth. For instance, Goldsmith (1969) finds a positive correlation between financial development and economic growth from 35 countries over the period 1860-1963. King and Levine (1993a) examine 77 countries over the period 1960-1980 and find that there is a strong positive relationship between financial development and economic growth. Hondroyiannis, Lolos and Papapetrou (2005) investigate the relationship between the development of the banking system and the stock market, and the economic performance of Greece over the period 1986-1999. The findings suggest that the development of banks and the stock market could promote economic growth in the long run. These studies mainly focus on the impact of financial development on economic growth. Alternatively, some researchers emphasise the role of liquidity in explaining economic growth. Bencivenga, Bruce, and Starr (1996) demonstrate a model emphasising that accommodating investors' demand for liquidity is an essential function of financial markets, and the reduction of transaction costs could bring higher levels of capital stock and national income. Levine and Zervos (1998) examine empirically the impact of liquidity on long-term growth. They use data for 47 countries from 1976 to 1993, and confirm that there is a strong positive relationship between liquidity and economic growth.

Although many empirical studies mentioned above investigate the role of financial development and economic growth, most of the studies analyse cross-sectional data; thus, the results may vary considerably across countries because of the differences in their institutional characteristics. Also, cross-sectional data analysis does not permit the investigation of the direction and intensity of causal links. Moreover, the relationship between liquidity and various macroeconomic indicators has not been investigated rigorously yet. Therefore, chapter five investigates the effect of stock market liquidity on the various macroeconomic variables (GDP, unemployment, consumption and investment) as well as the two-way Granger causality test between liquidity and macroeconomic indicators.

To summarise, this thesis aims to: (i) investigate the existence of the liquidity-volatility spillover effect among international stock markets; (ii) explore an alternative liquidity proxy that could capture as many facets as possible and includes commonality in liquidity with the alternative liquidity proxy; and (iii) investigate the relationship between market liquidity and various macroeconomic variables for developed and developing market groups.

The thesis contributes to the literature in several ways. The main contributions could be presented as follows.

- It shows that liquidity-volatility is high and persistent for the selected countries. The study finds consistent, significant liquidity-volatility spillover effects between the UK and selected East Asian countries as well as between the UK and the US from both tests (GARCH-M model and Granger causality test) except the group for the UK and Japan.
- It shows that an alternative liquidity measure (across-measure) which is extracted across a number of different measures of liquidity is correlated across different liquidity measures in the UK market. Thus, the across-measure could be considered as the supplementation for the possible defect

in empirical analysis which could stem from multidimensional characteristics of liquidity proxy.

- It shows that the across-measure is contemporaneously correlated with stock returns and that shocks to returns can predict future liquidity levels in the UK market, which is consistent with the evidence of the US market. Also, it investigates whether the alternative liquidity measure is priced or not in the UK market. The evidence regarding the pricing of the across measure is weaker than the evidence of the US market.
- It provides explicit evidence confirming that liquidity variables have some ability to predict macroeconomic indicators, but this is country- and variable-specific. The study looks into the effect of stock liquidity on macro variables for Asia-Pacific countries and finds that some of liquidity variables are able to predict macroeconomic variables even after controlling for financial variables; but these variables are not consistent over the selected six countries.
- The study shows the relationship between liquidity (global and national) and macroeconomic variables. It finds that liquidity Granger causes macroeconomic variables more frequently than macroeconomic variables Granger cause liquidity. Also global liquidity has a stronger impact on macroeconomic variables than national liquidity, while macroeconomic variables have a stronger impact on national liquidity than global liquidity.
- It shows the relationship between liquidity and macroeconomic variables with different sizes of portfolio. It finds that large firms' liquidity appears to have a stronger effect on macroeconomic variables. As regrouping the selected countries into developed and developing markets, it shows that

changes in macroeconomic variables have a stronger impact on small national firms' liquidity for developed markets, while changes in macroeconomic variables have a stronger impact on large national firms' liquidity for developing markets.

The structure of the thesis is as follows. In Chapter Two, the established theoretical and empirical literature that is relevant to the market-making process, trading mechanisms, asymmetric information, and liquidity is thoroughly reviewed. The main purpose of this literature survey is to provide the theoretical foundations that have been applied to the empirical investigation; thus, it could provide the background of prominent empirical debates or inadequate issues by highlighting prior studies and pinpointing any possible gaps. Because Chapter Two touches on the broad viewpoints of the literature, a specific literature review for each of the issues examined in this thesis is presented at the beginning of each empirical chapter.

Chapter Three is the first empirical study that focuses mainly on cross-country and time-series properties of market-wide liquidity. Since commonality in liquidity exists across stocks in a market, it could possibly detect commonality in liquidity across international markets because of financial integration. Thus, it assumes that liquidity risk in one market can spill over to other markets. This chapter investigates the relationship between aggregate stock market liquidity and level of liquidity volatility, and liquidity-volatility spillover effects between the UK and Asian countries (Japan, Hong Kong, China and Korea) as well as between the UK and the US. Two liquidity proxies are used (absolute bid-ask spread and proportional bid-ask spread). There are significant positive liquidity-volatility spillover effects in the UK-US group, the UK-China group and the UK-

Korea group, while the existence of liquidity-volatility spillover effects between the UK and Japan is rather ambiguous.

Chapter Four is relevant to the issue of multidimensional characteristics of liquidity proxy. Since liquidity is an elusive concept, researchers have used different proxies to capture liquidity and test if it is priced mainly for the US market. For the first time, the chapter tests if commonality in liquidity is priced in the UK, extracting common factors from different liquidity measures and creating an across-measure that captures as many facets of liquidity as possible, following Korajczyk and Sadka (2008). Different specifications are used to test if the across-measure is priced. It shows weaker evidence regarding the pricing of the across-measure compared to the US. Only turnover and B/M as characteristic are priced after controlling for FF factors, across and within measures contrary to US evidence.

Through the chapter three and four, the study shows that the commonality in liquidity in the UK is correlated with the liquidity of Asian markets. It clearly confirms that the market-wide commonality in liquidity can create the commonality in liquidity across countries due to the market linkages.

Chapter Five examines the impact of liquidity on economic conditions. This is the first empirical study investigating the effect of stock market liquidity (national and global) on macroeconomic variables such as GDP, unemployment, consumption and investment for developed and developing Asia-Pacific economics following US evidence by Naes, Skjeltorp, and Odegaard (2011) and G6 evidence by Galariotis and Giouvris (2013). From the Granger causality tests, it shows that liquidity Granger causes liquidity. Global liquidity has a stronger impact on macroeconomic variables than national liquidity, while macroeconomic variables have a stronger impact on national liquidity than global liquidity. This applies to both groups of developed and developing markets. The study finds that large firms’ liquidity appears to have a stronger effect on macroeconomic variables compared to the liquidity of smaller firms in the six Asian countries, which is consistent with Galariotis and Giouvris (2013) but contrasts with Naes, Skjeltorp, and Odegaard (2011). Additionally, changes in macroeconomic variables have a stronger impact on small national firms’ liquidity for developed markets while for developing markets they have a stronger impact on large national firms’ liquidity.

Finally, in Chapter Six the main results of the thesis are summarised and concluding remarks are made.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Chapter One described the purpose of this thesis. This chapter reviews the existing literature in the fields under examination in the thesis. This is done to reveal controversies in the existing literature by critically evaluating and identifying those areas that have received insufficient attention to date.

This chapter is organised as follows: Section 2.2 examines the existing theoretical literature that seeks to explain market behaviour in terms of asset prices that do not necessarily reflect full-information expectations of value because the existence of frictions in the trading environment. Section 2.3 reviews the components of trading costs and how they can be measured. The focus of this section is whether various liquidity measurements in the literature are sufficient in simultaneous use because different liquidity measurements capture different dimensions. Section 2.4 provides a review of the scant literature existing on the role of liquidity in asset pricing models. Section 2.5 contains a review of the nature of volatility and spillover effect across international stock markets. Section 2.6 provides a review of the theoretical and empirical literature on the relation between financial market development and economic growth.

2.2 THEORETICAL DEVELOPMENT REGARDING MARKET BEHAVIOUR

Whilst most of the work in the field of modern finance tends to be empirical in nature, much of the basis of the current theoretical understanding of the efficiency by which security prices impound all information stems from the work of Fama

(1965, 1970). This is known as the efficient market hypothesis. According to the efficient market hypothesis (hereafter EMH), trades are made at a price that is equal to the best estimation of the asset value at which all available information is incorporated. This is the fundamental value v of the asset. Formally, EMH states that

$$P_t = \mu_t \equiv E(v|\Omega_t) \tag{2.1}$$

where μ_t is the market-makers' estimate of the security's value v at time t, and Ω_t denotes the information available at time t. The very last term $E(v|\Omega_t)$, shows that the expected value of v is conditional on information Ω_t. The conditional expectation μ_t can change only if new information arrives in the market. Thus, the revision of the asset value estimated by this new information between time t and t+1 is denoted as $\varepsilon_{t+1} = \mu_{t+1} - \mu_t$. This shows that the error term captures the effect of news and cannot be forecasted using past information. Thus $E_t\varepsilon_{t+1} = 0$ and $(\varepsilon_{t+1}|\Omega_t) = 0$, which implies that the expectation of μ_{t+1} at time t is simply μ_t:

$$E[\mu_{t+1}|\Omega_t] = \mu_t \tag{2.2}$$

As $P_t = \mu_t$ at each trade, it follows immediately that

$$P_t = E(P_{t+1}|\Omega_t) \tag{2.3}$$

The equation above contains an important implication for the dynamics of stock prices. Namely, the best predictor of future prices, given currently available information, is the current price. Hence, changes in prices cannot be predicted from past information and particularly not from previous price changes. Fama (1970) identified three levels of market efficiency based upon the type of information reflected in the security price: (i) *weak form* market efficiency in which prices reflect the information contained in historical prices; (ii) *semi-strong form* market efficiency in which prices reflect the value of information that is publicly available; and (iii) *strong form* market efficiency in which prices reflect the information content of all available information, including private information. However, there are many contentious issues surrounding the application of EMH in empirical research. An often-cited criticism of EMH is the existence of financial market anomalies. Financial market anomalies are cross-sectional and time series patterns in security returns that include the following: returns in January tend to be higher than other months of the year (French, 1980; Keim, 1983; Reinganum, 1983); stocks appear to exhibit seasonal intraday return patterns, with most of the average daily return coming at the beginning and end of each day (Harris, 1986); stock prices move too much to be consistent with news about future dividends (Shiller, 1981a, 1981b); returns are negatively correlated with market capitalisation (Banz, 1981; Reinganum, 1981). More importantly, Grossmand and Stiglitz (1980) and Tirole (1982) argued that an informationally efficient market is impossible because producing information has a cost, and market prices cannot perfectly reflect all available information. If this was the case, investors who spend resources to obtain information would receive no compensation.

There are two types of traders under asymmetric information, “informed” and “uninformed”. Informed traders are likely to act and take positions in the market based on their information. Thus, informed traders sell and buy when they believe that a price is deviating from its fundamental value. This moves the price closer to its fundamental value. However, it is possible that prices might deviate from their fundamental value for substantial periods because of noise traders in the market. Under this circumstance, the informed have to take into account the behaviour of the noise traders. Prices that deviate from the equilibrium under specific trading mechanisms have been studied extensively, which could be a starting point for market microstructure research. The next section discusses the early development of market microstructure theory and the background of some issues that are related to our empirical investigations such as the liquidity-volatility spillover effect, multidimensional characteristics of liquidity, and the impact of liquidity on economic conditions.

2.2.1 INVENTORY MODELS

2.2.1.1 GARMAN'S MODEL

The equilibrium price is the price at which quantity demanded equals quantity supplied based on the assumption that buyers and sellers are in balance. If buyers and sellers, however, arrive at different points in time, this could create temporal imbalances in prices. Garman (1976) analyses this phenomenon by utilising a stochastic exchange process. In this model, there is a single risk-neutral, monopolistic dealer who sets prices to maximise expected profit per unit of time to avoid bankruptcy or failure. This market-maker's only decision is to set bid and ask prices at which the difference between two prices is optimal; but the market-maker selects bid and ask prices only once at the beginning. Buy and sell orders are assumed to follow a Poisson distribution with stationary arrival rate functions $\lambda_a(P)$ and $\lambda_b(P)$. Therefore, the uncertainty in the model arises only from the arrival of buy and sell orders, which are represented as independent stochastic processes. Under these assumptions, Garman's market-maker is supposed to maintain a level of cash and stock inventory for maximising profits per unit of time. It implies that the level of cash and stock at each time depends on the arrival of buy and sell orders.

The model has stylised assumptions that do not allow changing prices and borrowing cash; buy and sell orders follow independent stochastic processes; and inventory follows a random work with zero drift. Thus, under these assumptions, failure is certain over a finite time period (T). This is the classic gambler's ruin problem. This means that market makers must actively adjust prices in relation to inventory, rather than simply adjusting spreads as in the Demsetz model. In this model, the spread arose, in part, because of the need to reduce failure probabilities. A particular limitation of the Garman model is the fact that whilst inventory determines the market-maker's viability, it is not explicitly incorporated into the market-maker's decision problem because of the assumption that the market-maker can only set prices at the beginning of the trading period. This restriction severely limits the applicability of the model in a situation in which prices continually change. Amihud and Mendelson (1980) address this problem by explicitly incorporating inventory into the market-maker's pricing problem. In this model, the dealer balances his inventory over time by changing his prices in each period of time. In other words, the dealer lowers (or raises) bid and ask prices in response to a growing (or shrinking) inventory that allows the dealer to achieve a preferred or target inventory position. Thus, this model predicts that the level of bid and ask prices is a monotonically decreasing function of the dealer's inventory. Finally, the optimal bid and ask prices exhibit a positive spread, and inventory is bounded above and below by exogenous parameters, which removes the capital constraints of the Garman model. This implies that the bid-ask spread arises from the market-maker's efforts to maximise profits rather than simply reduce probabilities of failure.

2.2.1.2 HO AND STOLL’S MODEL

The Ho and Stoll (1981) model extends the intuition of the Stoll (1978a,b) model, focusing on how a risk-averse dealer’s inventory, order processing costs, and adverse selection risk affect a dealer’s pricing. This model is significantly different from the model of Garman (1976) and Amihud and Mendelson (1980). For instance, the dealer is risk-averse and cannot hedge his inventory exposure. The dealer also maximises the expected utility of final wealth. Thus, the model demonstrates that variables such as the dealer’s cash, inventory and base wealth positions affect the dealer’s optimal pricing strategy, which is determined by setting bid and ask prices. The important findings of the optimal pricing strategy in the model are that inventory causes the dealer to increase and decrease both bid and ask prices by the same amount; thus inventory affects the level of bid and ask prices but does not affect the magnitude of spread. Also, the spread increases to compensate for inventory and portfolio risks because of the assumption of risk aversion. Finally, the spread is independent of the inventory level. In other words, the spread is not affected by the dealer’s inventory position, but the spread reflects the dealer’s risk aversion.

However, O’Hara (1995) points out unrealistic assumptions made by Ho and Stoll’s model. Firstly, since the model is based on a finite horizon, traders with a long horizon would always be better off than traders with a short horizon. Secondly, the spread is not independent of the market-maker’s inventory because the market-maker faces dual uncertainty (orders and prices). To deal with this multiple uncertainty, the market-maker needs to change the size of the spread, and the size and value of the inventory.

Dealer inventory was among the first market frictions studied by market microstructure, and it provides important insights into the behaviour of market prices associated with transaction costs. There is an alternative explanation of market prices that does not rely on transaction costs but rather on the role of information. Hence, information-based models are discussed in the next section.

2.2.2 INFORMATION-BASED MODELS

This section discusses various models that explain market behaviour that does not rely only on transaction costs, but also relies on asymmetric information. The essential feature of information-based models is that the trading process involves decisions made by traders who have superior information compared to others. These informed traders buy when they know a stock's current price is too low, and they sell when they know it is too high. From the market-maker's point of view, the market-maker always loses with informed traders and bears the costs of these trades; thus, the market-maker must be able to offset these losses from uninformed traders. These gains arise from the bid-ask spread. Rational, competitive market-makers set their bid and ask prices accordingly, and more extreme information asymmetries lead to wider bid-ask spreads.

2.2.2.1 COPELAND AND GALAI MODEL

The first attempt to formalise this concept of information costs was by Copeland and Galai (1983) using a static one-trade framework. They assume that a dealer who is risk neutral sets bid and ask prices to maximise expected profit; the market-maker has unlimited capital; and there is no bankruptcy in the model. The most important contribution of this study addresses the probabilistic structure. The market-maker knows that any given trade comes from an informed trader with probability π_I and from an uninformed trader with probability $(1-\pi_I)$. The market-maker assumes that some uninformed traders will buy with the probability of π_{BL} and sell with the probability of π_{SL}. Also, uninformed traders will not trade with the probability of π_{NL}. The expected loss of the market-maker from trading with informed traders is $(P-P_A)+(P_B-P)$, while the expected gain of the market-maker from trading with uninformed traders is $\pi_{BL}(P_A-P)+\pi_{SL}(P-P_B)+\pi_{NL}(0)$ where P_A denotes ask price, P_B denotes bid price and P denotes the true value of an asset. Since the market-maker does not know the type of trader he is dealing with, he weighs his expected gains and losses by the probability of informed and uninformed trading. Namely, $-\pi_I(P-P_A)+(P_B-P)+(1-\mathrm{\pi_I})[\pi_{BL}(P_A-P)+\pi_{SL}(P-P_B)+\pi_{NL}(0)]$ gives the market-maker's objective function to maximise profit. This formula clearly shows that the size of bid and ask price is a function of the market-maker's maximisation problem. Also, it shows that when the positive probability of trading is by the informed trader, the bid-ask spread will always be larger than zero; otherwise the market fails. This model provides an important characteristic of bid-ask spread, but it does not involve multi-periods trading. More importantly, this model misses the point that the trade itself could reveal the underlying information and so affect the behaviour of prices.

2.2.2.2 GLOSTEN AND MILGROM MODEL

Glosten and Milgrom (1985) developed a model that demonstrates how the market-maker learns information from the order flow and assimilates it into his price. Namely, informed traders make a profit from trading when prices are not at full information levels, and so informed traders trade as much as possible. Since such behaviour shows the information of the informed trader, the market-maker quickly adjusts prices to incorporate this information. In the model, the market-maker posts bid and ask quotes that are subsequently executed against by their customers. The bid-ask spread depends on a number of factors such as: (i) the probability of trade by the informed trader; (ii) the stochastic process of the stock; and (iii) the elasticity of demand. It follows that if these factors remain unchanged, the bid-ask spread would remain unchanged. All market participants and the market-maker are assumed to be risk-neutral and to act competitively. The informed traders receive an informative signal about a security's value prior to trading. Each trader arrives in the marketplace sequentially, that is one agent at a time, and may choose to buy or sell. Each trader may trade only once and the size of the order is equal to one unit. Thus, if an informed trader wishes to trade further, they are obliged to return to the pool of traders and wait once more.

The ask price is simply what the market-maker believes the value of the security is, and the bid price is simply the market-maker's expected value of the asset given that a trader wants to sell the asset to the market-maker. The bid and ask price is regret-free because the market-maker believes the price is fair.

Thus, a bid-ask spread exists due to effects that are entirely independent of inventory effects. It depends on the nature of the underlying information and the number of informed and uninformed traders. Market-makers face an adverse selection problem in that they will lose to informed traders. Thus, the market-maker quotes higher prices for buyer-initiated transactions (ask) and lower for seller-initiated transactions (bid). In this model, the spread arises as a result of the revisions in the asset's value conditioned by observed trades, while in the model of Copeland and Galai, the spread arises as a result of balancing expected gains and losses. Under the model, a high degree of asymmetric information can cause market failure under some conditions. For instance, if there are too many informed traders in the market, the market-maker has to set a wider spread, which could result in market failure due to the lack of trade. Although this model provides an important insight into the role of asymmetric information in the market-maker's pricing decision, it suffers from restricted order size because only one unit of each asset can be traded each time.

Easley and O'Hara (1987) expand on the Glosten and Milgrom model by incorporating the possibility of variation in trade sizes based on the assumption that an informed trader has a greater incentive to submit larger orders than an uninformed trader. They argue that the size of the transaction affects the bid and ask prices by revealing the type of agent who has submitted the order. They also incorporate the possibility that there is no information, and therefore trading activity provides a signal not only about the quality of information but also about the existence of information. There are two possible equilibria in this model. The first equilibrium arises where informed traders can be identified by their large trades, and therefore small trades are undertaken by uninformed investors. In this equilibrium, since the market-maker does not face an adverse selection problem, it does not have any impact on the spread for small trades. The second possible equilibrium could occur when the informed trader strategically submits both large and small orders to improve the prices for a large trade. This leads to a positive correlation between trade size and the size of spread.

2.2.3 THE STRATEGIC BEHAVIOUR OF AN INFORMED TRADER

The Glosten and Milgrom model is an example of where all the parties in the market behave in a competitive manner. The informed traders know more than the market-maker and the uninformed traders. Because the informed traders keep on trading based on their information, eventually the information they have is fully revealed in the trading price. Under competition, traders with private information would have an incentive to act strategically in order to maximise their profits. Models based on these strategic aspects of information are collectively referred to as strategic trader models. Kyle (1985) was one of the first scholars to examine the behaviour of market-makers with a strategic trading framework.

2.2.3.1 SINGLE TRADE SETTING

Kyle's (1985) informed trader receives exclusive information about the liquidation value (v) of an asset that is stochastic and normally distributed: $v \sim N(p_0, \Sigma_0)$. In addition, there are liquidity traders who submit their orders. Their aggregate trade quantity (μ) is normally distributed with mean 0 and variance σ_μ^2,, which is independent of asset value (v). Kyle's model examines the behaviour of market-makers when facing insiders and liquidity traders. In order to maximise the trading profit, a single insider trader and a market-maker take the insider's trading strategy into account when updating beliefs about the future value of an asset when setting the equilibrium price. Thus, price is set after the orders are placed in a batch auction market. Under this model, order flow is informative with prices responding to trading activity. The market-maker is simply acting as an order processor, setting the clearing price.

The main property of this model is that information is gradually incorporated into prices across time. In the long run, prices will reflect all superior information, implying efficiency. So an uninformed observer’s expectation of the future price is today’s price. However, the model has certain shortcomings. In particular, there is no consideration for price contingent order submission, and informed trading is restricted simply to a single trader. Also, superior information is disseminated not through private channels but rather through public channels. Thus, there is no competition because of the monopolistic informed trader.

2.2.3.2 MULTIPLE INFORMED TRADERS: KYLE (1984)

The previous model was concerned with a single informed trader who traded in a sequential auction model. This next model is concerned with multiple informed traders and market-makers trading over a finite period of time. An important generalisation of Kyle’s model allows for multiple informed traders. If an informed trader is no longer a monopolist, the other informed traders could affect the prices, hence the return to private information. Since traders behave strategically, the actual trading mechanism is important because it determines traders’ order strategies. Thus, it is important to investigate the effect of multiple informed traders on market behaviour. Kyle (1984) introduces a three-date framework involving N speculators (informed traders) and M market-makers. The model shares a number of similar characteristics to Kyle (1985), but it differs in its approach over the liquidating period of time. All contracts are assumed to liquidate at the end of time 2 because trading takes place only at two dates in this model. Consequently, the adjustment of prices to information over time cannot be addressed in this model; but the price behaviour is based on the relationship among multiple informed traders, information revelation and noise trading.

In this model, there are two sources of information, one private and the other public. The public signal is observed by all market participants, whereas the private signal is known only to informed traders. Also, multiple informed traders are endogenous; in other words, the number of informed traders is determined within the model. Since individual profits are generated by using superior information, which is available to informed traders, an increase in the number of informed traders is expected to lead to a decrease in individual profits. This is because the information now needs to be shared by an increased number of informed traders. So the aggregate number of traders will affect the size of each individual trade. Having indicated that changes in optimal trading size and individual profits stem~~s~~ from endogenous informed traders, the model introduces increased noise trading and the amount of public information.

The other important change introduced in the model is changes in the amount of public information. Again, if the number of informed traders is given endogenously, then an increase in the amount of publicly available information will result in an immediate decrease in future profits because the advantage of holding superior information has now been dissipated. Also, when the information that used to be available only to informed traders becomes publicly available information, some informed traders could leave the market because of the absence of an advantageous position. Therefore, their information is no longer impounded on prices.

2.2.4 SUMMARY

The models discussed in this section provide an overview of the literature in the area of market microstructure, and highlight the importance of liquidity in market-making. Market microstructure models suggest that besides being a source of costs, the trading process can also be a source of risks for market participants. So investors require compensation not only for the expected trading costs associated with illiquidity but also for the additional risks (future trading costs for holders). For both of these reasons, illiquidity could affect equilibrium prices, which creates a link between the field of market microstructure and that of asset pricing.

2.3 MEASURING MARKET LIQUIDITY

There is no common definition of liquidity. Generally, liquidity denotes the ability to trade large quantities quickly, at a low cost, and without moving the price. The liquidity measures are generally classified into four categories which include (Wyss, 2004):

- Market depth or the ability to trade large quantities with little change in prices.
- Tightness, or the gap between bid and ask prices.

- Immediacy or liquidity, as the ability to trade quickly/the waiting time between trades is the measure for trading time.
- And resiliency or the ability to buy or to sell a certain amount of an asset with little influence on the price.

Liquidity is not a simple concept to explore because these four concepts are not entirely exclusive from each other. Additionally, there is no one superior proxy to capture all these four dimensions. Since it is not directly observable, a number of liquidity measures have been suggested in the literature. This section presents various liquidity proxies and delivers the topic which will discuss in the later chapter.

2.3.1 LIQUIDITY BASED ON TRANSACTION COSTS

Among the transaction costs measures, the bid-ask spread and its variants are the indicators of market liquidity that are used most commonly. A market-bid is the highest price at which a dealer is willing to buy a stock, and at which an investor intends to sell. A market-ask is the lowest price at which the dealer is willing to sell the stock. Since the dealer posts both the bid and ask quotes, the spread between these quantities can be interpreted as the price that the market pays for the liquidity services offered by the dealer.

Absolute bid-ask spread (ABS) is the average difference between the best ask and the best bid prices

$$\mathrm{ABS_t} = \frac{1}{\mathrm{T}}\sum_{\mathrm{t}=1}^{\mathrm{T}}(\mathrm{A_t} - \mathrm{B_t}) \qquad (2.4)$$

where A_t denotes the ask price, B_t the bid price, and ABS_t the absolute bid-ask spread at time t. If this spread is normalized by the mid-price $(A_t + B_t)/2$, one obtains the proportional bid-ask spread (PRO):

$$PRO_t = \frac{1}{T}\sum_{t=1}^{T} \frac{A_t - B_t}{(A_t + B_t)/2} \tag{2.5}$$

The proportional spread can also be obtained by using the logarithm of the bid and ask price in equation (2.33). Even though, the spread itself represents a measure of transaction costs, rather than a liquidity proxy in the pure sense, in a modern market, high transaction costs represent a source of a low liquidity. However, the bid-ask spread is a good measure for the cost of sales for a small number of stocks, but this measure is not a good measure for the cost of sales for a large number of stocks (Acharya and Pedersen, 2005). Another problem is that it is time varying, so it may not be a good measure of actual trading costs. Often quotes are not always available in all markets and for all time periods (Lesmond, 2005).

2.3.2 EFFECTIVE SPREAD

The transaction costs at time t are equal to

$$Q_t(P_t - P_t^*) \tag{2.6}$$

where P_t^* is equal to the equilibrium price, or fundamental value, and P_t denotes the transaction price at t and the variable Q_t indicates whether the transaction was buyer-initiated (buy, Q_t=1) or seller-initiated (sell, Q_t= -1).

From this, the spread can be estimated by:

$$S = \frac{1}{T}\sum_{t=1}^{T} 2Q_t(P_t - P_t^*) \tag{2.7}$$

where T is the number of observations over a given period and P_t^* is the equilibrium price, and P_t is the transaction price. The equilibrium price is replaced by the midpoint of bid and ask quotes for the effective spread which follows:

$$S^E = \frac{1}{T}\sum_{t=1}^{T} 2Q_t(P_t - M_t), \quad M_t = \frac{A_t + B_t}{2} \tag{2.8}$$

Data on the buy and sell indicator Q_t are not always available, so a feasible measure is the absolute difference between the transaction price P_t and the midpoint of bid and ask quotes. Thus, the effective spread can be estimated by:

$$S^E = \frac{1}{T}\sum_{t=1}^{T} 2|P_t - M_t| \tag{2.9}$$

The effective spread can be seen as a measure of a transaction's impact on the price because it measures the deviation of the actual execution price from the mid-price prevailing just before the transaction. In practice, an order is spilt over time which needs to be obtained by comparing the average price over the entire order with the mid-quote at the time at which the first transaction is made. Thus, it is very difficult to reconstruct total orders from transaction~~s~~ records. Also, it does not have information which tells whether a transaction is made from buy or sell orders.

2.3.3 REALIZED SPREAD

The presence of informed traders will cause market prices on average to rise after buying and to fall after selling. Due to these adverse price movements, market makers earn less than the effective spreads for their provision. Market making revenue net losses to better-informed traders can be measured by the reversal from the trade price to the post trade value. The realized spread captures the extent of reversal which is calculated by:

$$S^R = \frac{1}{T}\sum_{t=1}^{T} 2Q_t(P_t - M_{t+1}) \tag{2.10}$$

The realized spread is equal to:

$$S^R = E(\Delta P_t | P_{t-1} = B_{t-1}) - E(\Delta P_t | P_{t-1} = A_{t-1}) \tag{2.11}$$

where $\Delta P_t = P_t - P_{t-1}$, and A_{t-1} is the ask price. This implies that the transaction at time t-1 is initiated by a buyer and B_{t-1}, the bid price at time t-1, is the transaction initiated by a seller. The equation shows that the realized spread is smaller than the absolute bid-ask spread.

2.3.4 VOLUME-BASED LIQUIDITY

The measurements of the spread discussed above require transaction prices and bid-ask quotes. Very often, however, information for the bid-ask spread is not available. Thus, estimation of the spread based on volume is usually preferred. There is also a relation to the time dimension since higher volume leads to a shorter time needed for a certain number of shares to be traded. Thus, the values of volume-related measures should be higher in order to indicate high liquidity.

Brennan and Subrahmanyam (1995) find that trading volume is an important determinant of the measure of liquidity. Brennan, Chordia, and Subrahmanyam (1998) and Chordia, Subrahmanyam, and Anshuman (2001) use dollar trading volume as a liquidity measure in asset pricing tests and find that volume has a significant and negative relation with risk-adjusted stock returns. Chordia, Roll, and Subrahmanyam (2000) also show a strong cross-sectional relation between trading volume and liquidity measures such as the bid-ask spread.

$$\mathrm{V} = \sum \mathrm{P_i} \times \mathrm{Q_i} \tag{2.12}$$

where $\mathrm{P_i}$ is prices and $\mathrm{Q_i}$ is quantities of the i trade during a specified period. Trading volume (V) represents the number of shares traded in a certain time interval which can be used daily, weekly, and on an annual basis or any other time interval which is appropriate for analysis.

Turnover

Turnover is the ratio of share volume to the outstanding amount of the stock. The formula is as follows

$$\mathrm{TO_{i,d,t}} = \mathrm{VO_{i,d,t}}/\mathrm{NSH_{i,d,t}} \tag{2.13}$$

where TO is turnover rate, VO is the volume, NSH is the outstanding stock of the asset, and P is the average price of the asset *i* on day *d* of month *t*. Turnover is more adequate than trading volume as a measure of liquidity, because it makes possible a comparison between different stocks. Theoretical motivation for using turnover as a liquidity proxy goes back to Demsetz (1968) and Glosten and Milgrom (1985) and Constantinides (1986) among others. Demsetz (1968) show that the price of immediacy would be smaller for stocks with high trading frequency since frequent trading reduces the cost of inventory controlling. Glosten and Milgrom (1985) shows that stocks with high trading volume would have a lower level of information asymmetry to the extent that information is revealed by prices. Constantinides (1986) shows that investors would increase their holding periods (thus, reduce turnover) when a stock is highly illiquid. Higher turnover means stocks can be traded quickly with low time delay costs. Thus, theoretically, it is negatively related to bid-ask spreads and expected returns. Turnover, however, captures trading frequency but fails to account for the cost per trade which varies considerably across assets. Also, there is a scaling problem with turnover because it is likely to be nonlinear with respect to the bid-ask spread. Lesmond (2005) argues that turnover is downward biased for low liquidity markets. This downward bias is practically manifested by reduced trading volume that specifically affects turnover.

2.3.5 LIQUIDITY BASED ON TRANSACTION PRICES

As quotes may not be binding or the spread may not be available, the spread based on transaction prices is usually preferred. Roll (1984) proposes a model for estimating spread using the time series of the prices at which trades were made. The basic idea of this model is that random orders made by investors will have an impact on the ask and bid price that are reflected in the mid-price. The transitory deviations around the mid-price are called bid-ask bounce and this bounce causes negative serial correlation between transaction returns.

The Roll model demonstrates that it is possible to estimate spread by computing the auto-covariance of transaction prices in the absence of transaction costs. Suppose that the transaction price is equal to the equilibrium price:

$$P_t = P_t^* \tag{2.14}$$

This implies that the spread is zero, and if the variation of asset price is a random walk then:

$$\Delta P_t^* = P_t^* - P_{t-1}^* = \Gamma + U_t \tag{2.15}$$

Where Γ is a constant equal to the unconditional expected value of the variation of equilibrium price (ΔM_t) in the time interval Δt, and U_t is a random variable with zero mean and variance σ_U^2, representing the revision of the equilibrium price generated in the period Δt by the unexpected arrival of public information. Also, it assumes that $E(U_t|\Phi_{t-1}) = 0$ where Φ_{t-1} is all public information such as the past transaction price and quote. If the price drift Γ is zero then it obtains:

$$\Delta P_t = \Delta P_t^* = U_t \tag{2.16}$$

Thus, the auto-covariance of the price variations is equal to:

$$Cov(\Delta P_t, \Delta P_{t-1}) = Cov(U_t, U_{t-1}) = 0 \tag{2.17}$$

Introducing transaction costs into the formula above to justify the existence of a constant spread whose midpoint is equal to the equilibrium price P_t^* changes the formula (2.43)

$$P_t = P_t^* + \frac{S}{2} Q_t \tag{2.18}$$

where Q_t is a dummy variable taking the value +1 for a buy and -1 for a sell order with equal probability, and S is a constant spread. Therefore, transaction-to-transaction return is:

$$\Delta P_t = P_t^* - P_{t-1}^* + \frac{S}{2}(Q_t - Q_{t-1}) = U_t + \frac{S}{2} \Delta Q_t \tag{2.19}$$

In order to estimate Roll's measure for the bid-ask spread, it requires additional assumptions which are:

- Probabilities of buying and selling are equal: $\mathrm{Pro}(Q_t = 1) = \mathrm{Pro}(Q_t = -1) = \frac{1}{2}$
- No autocorrelation in orders. Buy and sell market orders are serially uncorrelated $E(Q_t, Q_s) = 0$ for $t \neq s$
- No effect on the midquote. $E(Q_t \varepsilon_t) = E(Q_t \varepsilon_{t+1}) = 0$ for all t
- Constant (zero) expected returns. $E(P_t^* - P_{t-1}^*) = E(\varepsilon_t)$ thus it is constant and equal to zero for all t.

Under the assumptions of Roll's model:

$$\mathrm{Cov}(\Delta P_t, \Delta P_{t-1}) = \mathrm{Cov}\left[\left(U_t + \frac{S}{2}\Delta Q_t\right), \left(U_{t-1} + \frac{S}{2}\Delta Q_{t-1}\right)\right] = -\frac{S^2}{4} < 0 \tag{2.20}$$

The equation (2.49) shows that the existence of a bid-ask spread induces negative autocorrelation in the transaction price changes. Moreover, it yields Roll's measure of the absolute value of the bid-ask spread:

$$S = 2\sqrt{-\mathrm{Cov}(\Delta P_t, \Delta P_{t-1})} \tag{2.21}$$

Equation (2.50) is also known as Roll's measure. Stoll (2000) presents estimation of the Roll's measure for all stocks listed on the NYSE and Nasdaq. He calculates each stock's average daily serial covariance in trade-to-trade price changes over sixty-one trading days. Overall, for NYSE, the Roll's measure is 3.81 cents and 11.5 cents for Nasdaq. Obviously, the two exchanges have different characteristics but he finds that it is persistent even after controlling for market capitalization. The advantage of Roll's measure is that it requires only price to estimate liquidity (Lesmond, 2005). Lesmond (2005) and Bekaert, Harvey, and Lundblad (2007) show that Roll's measure is not a robust estimator of liquidity, especially when it is used within each individual country.

2.3.6 LIQUIDITY BASED ON PRICE IMPACT

One of the most popular methods to estimate transaction costs is the ILLIQ measure of Amihud (2002). The idea is to calculate Kyle's lambda, namely the price impact of trading, as the absolute price change on a particular day divided by the absolute order flow. This ratio is then averaged over a number of days to obtain a measure of illiquidity for a given period.

$$\mathrm{Amihud}_t = \frac{1}{D}\sum_{d=1}^{D}\frac{|\Delta P_{i,d}|}{V_{i,d}} \tag{2.22}$$

Where Amihud_t is illiquidity, $|\Delta P_d|$ and V_d is absolute returns and dollar volume on day d in month i. D is the number of valid observation days in month i for the stock. The price change measured as a return and larger Amihud measure implies that trading a stock causes its price to move more in response to a given volume trading reflecting lower liquidity. It is very useful when only daily data on prices and volume are available and the measure is strongly related to the proportional spread. However, it has drawbacks. For instance, the Amihud (2002) measure misses the concept of trading speed. This is because the measure does not take into account the number of non-trading days. Additionally, the Amihud measure can be easily overestimated by extreme values.

2.3.7 LIQUIDITY BASED ON ZERO RETURNS: LOT MODEL

Lesmond, Ogden, and Trzcinka (1999) have developed a percent-cost proxy based on the idea that transaction costs cause a distortion in observed stock returns. The intuition of this model is that if transaction costs prevent more informed traders from trading, then more zero return will be observed in a firm with large transaction costs because informed investors trade only when they expect their gains from trading on mispricing to exceed the trading cost.

The LOT model assumes that the unobserved "true return" $R^*_{j,t}$ of a stock *j* on day *t* is given by:

$$R^*_{j,t} = \beta_j R_{m,t} + \varepsilon_{j,t} \tag{2.23}$$

Where β_j is the sensitivity of stock *j* to the market return $R_{m,t}$ on day *t* and $\varepsilon_{j,t}$ is a public information shock on day *t*, they assume that $\varepsilon_{j,t}$ is normally distributed with mean zero and variance σ^2_j. Now let $\alpha_{1j} \leq 0$ be the percent of transaction cost of selling stock *j* and $\alpha_{2j} \geq 0$ be the percent of transaction cost of buying stock *j*, then the observed return $R_{j,t}$ on a stock *j* is given by:

$$R_{j,t} = R^*_{j,t} - \alpha_{1,j} \quad \text{when } R^*_{j,t} < \alpha_{1,j}$$

$$R_{j,t} = 0 \quad \text{when } \alpha_{1,j} < R^*_{j,t} < \alpha_{2,j}$$

$$R_{j,t} = R^*_{j,t} - \alpha_{2,j} \quad \text{when } \alpha_{2,j} < R^*_{j,t} \tag{2.24}$$

Actually, LOT have found that the frequency of zero daily return is greater for firms with larger trading costs. Firms with larger trading costs require a large accumulation of news to overcome the trading cost threshold and their returns of nonzero return days are expected to be larger. The advantage of this measure is that it requires only a time series of daily returns and no transaction volume data. Bekaert, Harvey, and Lundblad (2007) examine this measure in terms of credibility of the measure. They show that it is positively correlated with bid-ask spread for the limited periods when overlapping data are available and negatively correlated with trading volume. However, the assumption that there is no trading whenever prices do not move is not always valid. Even though there is trading, the price of stock may stay level due to no news about the stock in the market.

2.3.8 LIU MEASURE

Liu (2006) suggests a liquidity measure defined as the standardized turnover adjusted number of zero daily trading volumes over the prior t months. This measure of liquidity is specified below

$$\mathrm{Liu}_{it} = \left[\mathrm{NoZV}_{i,t} + \frac{1/\mathrm{turnover}_{i,t}}{\mathrm{deflator}}\right] * \frac{21}{\mathrm{NoTD}_t} \qquad (2.25)$$

where $\mathrm{NoZV}_{i,t}$ is the number of zero-trading days for stock i in month t, $\mathrm{turnover}_{i,t}$ is the turnover of the stock in the month t, and the deflator is 480,000 as suggested in Liu (2006). The number of zero daily trading volumes plays a major role in determining the liquidity measure. Adjusted turnover plays a secondary role because its value is between 0 and 1. If there are two stocks with the same integer number of zero daily trading volumes, it can decide that the stock with the larger turnover is more liquid. The multiplication by the factor $\frac{21}{\mathrm{NoTD}_t}$ normalizes the number of trading days in a month to 21. It makes the liquidity measure comparable over time because the number of trading days in a month can vary over time.

This section shows various liquidity proxies which are widely used in the literature. Even though these liquidity proxies are widely used in asset pricing research, there is no such thing as a superior proxy that is able to capture all facets of liquidity. Chai, Faff, and Gharghori (2010) emphasize the multi-dimensional characteristics of liquidity by looking at relations between six liquidity proxies and between the liquidity proxies and stock characteristics in the Australian stock market. They report low correlations between adopted liquidity proxies which imply that the proxies used represent different dimensions of liquidity. Also, they point out that the turnover measure shows a rather different pattern compared to all other liquidity proxies, and there is no evidence that the return reversal measure depends on stock characteristics. Brown, Du, Rhee and Zhang, (2008) show that the main determinants of commonality in liquidity are different for each market because each of the markets they look into has different trading mechanisms and the traders' behaviour is different. These two fundamental differences (dimensions of proxy and market structure) could lead to different conclusions. Therefore, it is very crucial to analyse markets using a type of liquidity measure which captures as many facets of liquidity as possible in order to reconcile the different relations observed.

2.4 ASSET PRICING MODELS AND LIQUIDITY

Having discussed the theoretical development of market microstructure, liquidity should now be considered as an important factor for analysing the market because it contains few important features; 1) the shortage of liquidity results in failure of market making, 2) individual stock's liquidity moves with market liquidity, 3) the liquidity risk cannot be diversified. Therefore, this section addresses the role of liquidity in asset pricing models.

As previously mentioned, the EMH shows that transaction prices reflect all the information available to market-makers at time t. The notion of "all available information" is problematic in an environment in which traders have asymmetric information as the market microstructure literature argues. Asymmetric information causes the difference between the execution prices for buy orders and sell orders. Thus, the bid-ask spread is part of the mechanism by which dealers incorporate the information contained from the order flow into the price process. O'Hara (2003) emphasises that in the model without the spread, all trade takes place at a single price reflecting the intersection of the supply and demand curves. However, if traders have a different information set, their expectations are not the same. Furthermore, asymmetric information creates a risk for uninformed traders because informed traders make a profit over uninformed traders. The presence of informed traders causes a spread to increase. This spread reflects orders that are not all synchronous. Therefore, O'Hara (2003) argues that liquidity and price discovery are important dimensions of asset markets. Because price discovery risks and liquidity can affect traders' risks and traders' returns, both liquidity and price discovery should affect asset returns.

Studies have shown that liquidity is an important attribute of an asset that investors take into consideration when making investment decisions. Thus, a vast number of studies examine the role of liquidity on asset pricing. Amihud (2002), Chordia, Subrahmanyam and Anshuman (2001), Chordia, Roll, and Subrahmanyam (2002), Pastor and Stambaugh (2003), and Chan and Faff (2005) find evidence that liquidity is a significant determinant of stock return. Some other studies, however, find inconsistent results. For example, Fama and French (1992) argue that liquidity is an important issue, but it does not need to be specifically measured and accounted for because it is already subsumed by the combination of size and book-to-market factors. According to Brennan and Subrahmanyam (1996), one explanation for the mixed results is that the asset pricing models used in those studies do not adjust adequately risk. The literature has been using two main models for pricing assets: the traditional capital asset pricing model (CAPM) and the Fama-French (1993) three-factor model.

The CAPM states that differences in average returns for a cross-section of stocks depend linearly on asset-betas. The first problem in testing this hypothesis is that individual stock returns are volatile, so one cannot reject the hypothesis that average returns across different stocks are the same. One possible solution is to sort stocks into portfolios where the sorting attempts to maximize differences in average returns. Grouping according to size and book-to-market are popular methods that produce a good spread of average returns. The second problem is that the betas are measured inaccurately. To minimise this problem, the model needs to assign individual stocks to a small number of portfolio betas. These portfolio betas are estimated using a time series regression of just a small number of portfolio returns. This grouping minimises error in estimating betas. However, Stambaugh (1982) and Fama and French (1993, 1996) present substantial empirical evidence that traditional CAPM does not suffice to explain variations in cross-sectional stock returns, and other factors beside beta exist that appear to be priced.

An alternative proposal is made by Acharya and Pedersen (2005) that is known as the liquidity-adjusted capital asset pricing model (LCAPM). It is derived from a framework similar to CAPM in that risk-averse investors maximise their expected utility under a wealth constraint. They do this by replacing the cost-free stock price, $P_{i,t}$, with a stochastic trading-cost-adjusted stock price, $P_{i,t} - \psi_{i,t}$, where $\psi_{i,t}$ is a trading cost of absolute amount, in an overlapping-generations economy. The LCAPM is presented as

$$E_t(R_{i,t+1} - C_{i,t+1}) = R_f + \lambda_t \frac{Cov_t(R_{i,t+1} - C_{i,t+1}, R_{M,t+1} - C_{M,t+1})}{Var_t(R_{M,t+1} - C_{M,t+1})} \tag{2.26}$$

where R_i is a gross return of stock i, the coefficient λ_t is the risk premium for covariance with the market return, R_M is a gross market return, R_f is a gross risk-free rate, and $C_{i,t}$ is a trading cost per price at time t ($C_{i,t} \equiv \frac{\psi_{i,t}}{P_{i,t}}$). Subscript *t* in the operators denotes that these operators are conditional on the information set available up to time *t*.

As a result of adjusting price by stochastic liquidity, the LCAPM has three covariance terms related to stochastic trading costs in addition to traditional market risk. It is easy to see that without the trading cost term, LCAPM (2.55) is equivalent to the traditional capital asset pricing model.

By assuming constant conditional variance or constant premia, the unconditional version of the model is derived as

$$E_t(R_{i,t} - R_{f,t}) = E(C_{i,t}) + \lambda\beta_i^1 + \lambda\beta_i^2 - \lambda\beta_i^3 - \lambda\beta_i^4 \tag{2.27}$$

where

$$\beta_i^1 = \frac{Cov(R_{i,t}, R_{M,t})}{Var(R_{m,t} - [C_{M,t} - E_{t-1}(C_{M,t})])}$$

$$\beta_i^2 = \frac{Cov(C_{i,t} - E_{t-1}(C_{i,t}), C_{M,t} - E_{t-1}(C_{M,t}))}{Var(R_{M,t} - [C_{M,t} - E_{t-1}(C_{M,t})])}$$

$$\beta_i^3 = \frac{Cov(R_{i,t}, C_{M,t} - E_{t-1}(C_{M,t}))}{Var(R_{M,t} - [C_{M,t} - E_{t-1}(C_{M,t})])}$$

$$\beta_i^4 = \frac{Cov(C_{i,t} - E_{t-1}(C_{i,t}), R_{M,t})}{Var(R_{M,t} - [C_{M,t} - E_{t-1}(C_{M,t})])} \qquad (2.28)$$

The risk premium is defined as $\lambda = E(\lambda_t) = E(R_{M,t} - C_{M,t} - R_{f,t})$. β_i^1 is similar to the traditional market beta of CAPM except for the terms related to trading cost. β_i^2 is liquidity risk arising from the co-movement of individual stock liquidity with market liquidity (commonality in liquidity). This is expected to be positively related to asset returns because investors require compensation for stock whose liquidity decreases when market liquidity goes down. β_i^3 captures the liquidity risk. If stock market liquidity unexpectedly decreases, a potential wealth reduction may follow for investors who hold stocks that are highly sensitive to market-wide liquidity. β_i^4 is shown to be negatively related to asset returns in the model because stocks that become more liquid in a down market are traded at a premium. Hence, the negative sign for β_i^4 is due to investors' willingness to accept low returns on such stocks.

Acharya and Pedersen (2005) empirically test the LCAPM on a sample comprising NYSE and AMEX stocks over the period 1962-1999, and find that the pricing effect of β_i^4 is strongest in the US market. Lee (2011) applies the LCAPM to a sample of 22 developed markets and 23 emerging markets. Overall, the aggregation of the LCAPM liquidity risks is also shown to be priced. These results indicate that liquidity risk through different channels is important in explaining stock returns. Moreover, liquidity risk is separated from market risk.

2.5 LIQUIDITY VOLATILITY AND SPILLOVER EFFECTS

2.5.1 LIQUIDITY VOLATILITY

A liquid market has traditionally been characterized as a market with low transaction costs (bid-ask spread) and stable price volatility. These two crucial characteristics rely heavily on the existence of noise in the market, which is often presented in the form of fluctuating liquidity and prices. In terms of price volatility, numerous studies examine the role of price volatility on asset pricing extensively. However, it provides little guidance to the relationship between level of liquidity (bid-ask spreads) and its own volatility (liquidity volatility). Therefore, this section focuses on liquidity volatility and spillover effects between international stock markets.

Private or asymmetric information is a central factor which creates informed and uninformed traders. Thus, the market maker strategically optimises their trading behaviour to minimise trading costs and compensate for potential loss due to trading with informed traders. This strategic process associated with asymmetric information is able to build an indirect link between liquidity level and liquidity volatility. Information asymmetry among investors can cause price volatility to increase. Kyle (1985) drives the equilibrium price dynamics in a model where a large trader possesses private information. He argues that informed traders know more information about the real value of the asset, and will place orders over time to maximise trading profit before private information becomes public information. Thus risk-neutral market makers observe net order flow and then set a price which is the expected value of the security. Under information asymmetry, more-informed investors trade on superior information against less informed investors. Hence, less informed investors face an adverse selection problem when they respond to noise trading, so they demand an additional premium for the risk of trading against better informed investors. This results in increasing price elasticity to supply shocks and price volatility. Campbell and Kyle (1988) show that the existence of noise trading in the market can explain the high price volatility. Namely, imperfect information for investors can cause stock price to be more volatile than when all investors are perfectly informed. Also, DeLong, Schleifer, Summers, and Waldman (1990) show that noise trading in the market can increase price volatility, as well as the risk of investing in the stock market. Wang (1993) also suggests that under asymmetric information, imperfect information increases the risk premia on stocks and increases price volatility. As it is mentioned at the beginning of this section, these studies examined the price volatility associated with asymmetric information. In order to explore the liquidity volatility, it can draw an inference from the empirical evidence that transaction costs (bid-ask spread) is correlated with trading volume.

Models based on private information ascertain the connection between bid-ask spreads and trading volume. Admati and Pfleiderer (1988) address the issue of transaction costs that is related to the volume indirectly. Their model shows that the Kyle-λ measures a market maker's price sensitivity to order flow and it is expected to be lower with high volume. Therefore, market makers will increase bid-ask spreads because they are more averse to order flows. Also Lee, Mucklow, and Ready (1993), Ahn, Cao, and Choe (1996) report that bid-ask spreads and depth are negatively related.

A significant contribution by Easley and O'Hara (1992) suggests that volume is important for the price and bid-ask spread determination. Trade in markets can arise from uninformed and informed traders, and they assume that informed traders are the risk-neutral allowing multi-informed traders in a market. They also assume that a market maker is risk-neutral and acts competitively. According to this framework, the trade is classified by three different characteristic events that determine the behaviour of investors. For instance, if there is an information event, all traders involved in the trade are informed traders who made a decision based on their full information. For an uninformed event, all traders are uninformed traders. Additionally, since informed traders are risk-neutral, they decide whether to sell or to buy, but only if there is an information event, while uninformed traders make transactions to sell, to buy or no trade in any circumstances based on their own motivation. Therefore, no trading conveys information too. This implies that the probability of no trading occurred with no information event is greater than the probability of no trading occurred with an information event. Based on this assumption, the market maker increases his probability that no information event has occurred due to the lack of trading. This change in the market maker's beliefs is reflected in the setting of his bid and ask price. The bid and ask price move in response to the absence of trade. Furthermore, when there is a greater volume (unanticipated volume), the market maker believes an information event has occurred. Hence, the size of the spread at time t+1 will be positively correlated with the volume up to time t.

Since volatility is a signal that is a consequence of instability in the market, the substance of liquidity volatility can be revealed by the process of a market maker's adjustment altering probability of information events. Since Easley and O'Hara's (1992) model still contains the uncertainty for the market maker over whether an information event has actually occurred, this uncertainty could be increased in reality, especially in active markets. The adjustment of new information could be done in minutes, and new information and no-information events could occur frequently thus the market maker needs to update their set of bid and ask prices continuously. This uncertainty associated with the adjustment for various information events could be reflected in the volatility of bid-ask spread. Therefore, it is expected that there is a positive relationship between the size of bid-ask spread and liquidity volatility because high volatility in liquidity could be the consequence of greater uncertainty in adjustment of the market maker's belief. Namely, higher liquidity volatility increases bid-ask spread (lower level of liquidity).

2.5.2 VOLATILITY SPILLOVER EFFECTS

Financial literature shows that market integration causes increasing asset prices and decreasing fixed costs due to commonly accepted accounting standards between financially integrated countries (Stulz, 1999; Martin and Rey, 2000). A more recent study by Nicolo and Ivaschenko (2008) documents the potential channels through which financial integration may have a positive impact on growth opportunities.

However, international market integration does not always deliver a positive impact on the stock market in terms of benefits associated with international diversification. International diversification offers improved portfolio returns and reduces the volatility which is achievable, only if there are low correlations in stock price movement. Goetzmann et, al. (2001) undertake an empirical test using 150 years of financial data pointing out the varying global correlation through time. They find that the highest potential diversification benefit associated with low correlation and during the depression, the correlation was high with low diversification benefits. This finding shows that there is a negative relationship between market correlation and international diversification. Thus, an increase in the degree of integration reduces potential benefits of international diversification because higher integration may bring greater external influences due to the close linkages between markets (Schwebach, Olienyk and Zumwalt, 2002).

In order to explore the issues arising from correlated stock market reactions, it is important to look at various theoretical channels through which high international market co-movement or correlation is created and often results in contagion.

2.5.3 VARIOUS THEORETICAL CHANNELS IN EXPLANATION OF MARKET CO-MOVEMENT

On Monday 19 October 1987, stock markets around the world crashed. Also, the recent subprime crisis which started in the US has spread worldwide. This section will discuss potential explanations of market co-movement in the international market. There are various theoretical models which are discussing possible channels through which any kind of shocks in one market transmit to other markets and could possibly result in contagion. These are information asymmetry, institutional investors & indexation, trade & financial linkage, and the inter-banking system.

2.5.3.1 INFORMATION ASYMMETRY (RATIONAL EXPECTATIONS)

In an informationally perfect market, the forecast error from the conditional mathematical expectation is uncorrelated with all the information at the present or earlier. Rational expectations assume that rational investors' subjective expectations equal the conditional mathematical expectations [1]. However, information asymmetry models assume that at least one party has better information than the others which creates a deviation from fundamentals in stock prices. Connolly and Wang (2003) claim that domestic investors may be confused with unobservable information from the previous foreign market return which is interpreted as noise and they incorporate the noise into their subsequent domestic trading. Therefore, returns in two markets are correlated by information asymmetry and the misleading stock price is transmitted to other countries through real economic linkages and informational linkages[2]. Finally, there is an alternative explanation of crisis and contagion. Yuan (2005) examines the stock market crisis and contagion based on a standard information asymmetry framework with borrowing constraints. Despite awareness about the signal of stock prices, informed investors' arbitrage ability is limited due to borrowing constraints; thus, their investment decisions do not fully incorporate into the stock

[1] EMH: the conditional expectation based on the information set needs to meet the property of orthogonality, so forecasted errors are uncorrelated with all the information at past and present. Thus the EMH says that all the relevant information is already incorporated into the current stock prices (Fama, 1970).

[2] Paolo (2007) support that excess price co-movement occurs as a result of real shocks but also misleading information about the fundamental value of stocks. It is transmitted to other countries through the real economic linkages and informational linkages.

price. Uninformed investors may reduce value of assets more than the price drop. Under this circumstance, the asset price collapse occurs without any public news or event and transmits to the other markets asymmetrically.

In terms of the relation between information asymmetry and liquidity, it has been widely reported that a higher level of information asymmetry can lead to wider spreads[3] and greater volatility[4]. As some investors have different ability to access or to analyse new information, the stock market reaction before and after releasing public information will increase the information asymmetry. Thus, it anticipates that informational linkages with asymmetric information flows could lead to deviation in stock prices, wider spreads, and greater volatility that could spill over to other markets.

2.5.3.2 INSTITUTIONAL INVESTORS AND INDEXATION

A few decades ago, stock transactions were more likely to be made by individual investors such as wealthy businessmen. Over time, stock markets have become more institutionalized, and the rise in the number of institutional investors has brought with it some improvements in market operations. Consequently, a big investment company with many specialized dealers has certain power to create a channel through which prices of stocks become correlated. A stock can be traded by dealers who are working in the same investment company sharing information provided by the company. Correlated stock movements in the context of market making is examined through the inventory hypothesis which argues that trading

[3] See e.g., Copeland and Galai (1983), Fishe and Robe (2004).
[4] See e.g., Kyle (1985), Li and Wu (2006).

behaviour depends on the total inventories in their firm[5] and depends on other stocks inventories[6]. The implication of these studies is that correlated inventories and adverse selection costs are shared by dealers working in a firm. Coughenour and Saad (2004) extend this idea further by examining liquidity co-variation and the influence of specialist firms on liquidity provision in the New York Stock Exchange. The findings show that specialized dealers within the same firm in NYSE share capital and information; thus, the trading manner is likely to be correlated. Also an individual stock's liquidity co-varies with the specialist's portfolio liquidity and when the capital in the firm shared by specialists becomes risky, liquidity co-variation increases with negative returns. Interestingly, there is another study which provides a different explanation of the behaviour of dealers. For instance, Naik and Yadav (2003) examine the dealer's behaviour for a sample of 20 stocks during 1994 in the London Stock Exchange and find strong evidence that in a decentralized market making system each dealer's trading behaviour in a stock depends on the ordinary inventory of that stock only. Furthermore, Kamara, Lou, and Sadka (2008) examine the relationship between sensitivity to aggregate liquidity shocks and institutional ownership in the cross section of firms. This study suggests that cross sectional divergence of systematic liquidity is associated with growth in institutional investing & indexation.

[5] Ho and Stoll (1983) argued that the dealer's trading behaviour should be governed by total inventories in the dealer's firm rather than individual's inventories.

[6] Froot and Stein (1998) show that firms' trading behaviour depends on inventories of the stocks in their firm and inventories from other stocks

2.5.3.3 TRADE AND FINANCIAL LINKAGE

In the literature focussing on financial contagion, the trading linkage is one of the persuasive channels through which a country's specific crisis could have global impact. If two countries trade directly, then the crisis in one of the countries could change the relative prices and quantities of goods traded in that country and have spillover effects in other economies.

However, there is an ongoing debate about whether trading linkages have large and significant effects on other countries. For instance, Eichengreen and Rose (1999) find strong evidence for the importance of trading linkages using the binary-probit model in 20 industrial countries between 1959 and 1993. They argue that the effect of contagion operating through trade is stronger than that of contagion spreading as a result of macroeconomic similarities. Similarly, it is supported by Forbes (2001) who finds that trading linkages are important. He analyses competitiveness effects (increase in exports due to the devaluation of its currency), income effects (impact of a crisis on income), and cheap-import effect (reducing relative price of its exports due to the devaluation of its currency). The findings show that real linkages between countries, such as trade, are important determinants of how a crisis can spread internationally. Moreover, Glick and Rose (1999) examine five different currency crises in 1971, 1973, 1992, 1994, and 1997 by comparing international trades and fundamental macroeconomic influences on the financial crisis contagion. They argue that crises tend to spread along regional lines through trade linkages rather than macroeconomic factors and show consistent evidence that currency crises spread due to trade linkages. Although, these papers find strong evidence for the importance of trade linkages, some other empirical papers argue that the main determinant of a contagion channel is not trade. Masson (1998) emphasizes that the Mexican and Thai crises could not be explained by trade linkages because of the small competitiveness effect. Among East Asian economies, the trade linkage was not strong enough to find much evidence in 1997. For example, the export share to Thailand constituted less than 4 percent of total exports for Asian countries and the regional competitiveness spillovers were small (Masson, 1998).

Most of the papers mentioned have got some limitations. The trading data is aggregated by industry; thus, it does not accurately measure competition in third markets, and some studies may suffer from omitted-variables bias since trade flows are highly correlated with other linkages such as financial flows, so it is very difficult to measure. Therefore, the cause of contagion could be mixed, taking an intermediate stance. Gregorio and Valdes (2001) argue that trade linkages can have some role, but are generally having some inter-connected repercussion of contagion with other factors such as financial linkages and macroeconomic variables.

2.5.3.4 INTER-BANKING SYSTEM

Risk in a financial system could emerge from liquidity risk in a financial institution which could transmit to other institutions through the inter-banking system. To prevent such an event, regulatory bodies have primarily focused on ensuring that individual institutions have sufficient funds to protect themselves from illiquidity shocks such as inter-banking loans. An inter-bank loan is expected to provide insurance and stability by allowing banks to access liquidity.

However, the interconnected banking system could be the transmission channel of a market crisis. Cifuentes, Ferrucci and Shin (2005) construct the model with two channels to examine the liquidity risk in a system of interconnected financial institutions. They argue that an idiosyncratic shock causes a reduction in the market value on the balance sheet; under this circumstance, the bank sells liquid assets to maintain their solvency. In other words, a distressed bank tries to sell illiquid assets in order to maintain its solvency. If the price of an illiquid asset falls enough, the bank will default causing other banks to go into distress as well. Similarly, Estrada and Osorio (2006) highlight that the individual liquidity risk turns into market risk by distressed banks even without the presence of elements such as bank runs, credit exposures, and regulatory capital requirements. More recently, a few papers have investigated the 2007 subprime crisis, which shows that the transmission of liquidity shocks is the main reason for the crisis through direct linkages between the balance sheets of financial institutions and indirect linkages through asset prices. Frank, Hermosillo, and Hesse (2008) demonstrate in detail the subprime crisis. The basic elements of the subprime crisis are asymmetric information from the complex structured mortgage products, rising interest rates, falling house prices, and credit downgrades. The evidence in this paper suggests that interaction between markets and funding illiquidity has increased sharply during the period of financial turbulence; thus, increasing financial integration and innovation can drive markets into liquidity crisis.

General findings of these studies show that markets may face potential benefits from improved market linkages during the market boom. However, these improved market linkages could increase the degree of spreading risks when the market is in downturn. Specifically, enhanced market linkages may have some disadvantages such as volatility surprises transferred to other stock markets (King, (1990) and Jeong (1999)). Additionally, Jang and Sul (2002); Caporale, Pittis, and Spagnolo (2006) suggest that extreme market conditions transmit to the international financial market through volatility spillovers. Therefore, the next section addresses market volatility and the spillover effect in the finance literature.

2.5.4 EARLY STUDIES ON VOLATILITY

The fundamental properties of volatility dynamics are volatility clustering (conditional heteroscedasticity) and long memory (slowly decaying autocorrelation). Clustering and long memory properties were first noted in Mandelbrot (1963). Since the possibility of volatility clustering prediction has been a central issue for many years, the volatility clustering has become partially predictable by Engle (1982) and Bollerslev (1986)[7]. Large changes tend to be followed by large changes and small changes tend to be followed by small changes. It means that volatility clustering is related to the thick-tailed distribution (Bollerslev, Engle and Nelson (1994)). Alternatively, Connolly and Stivers (2005) say that the volatility clustering is observed because the information arrives in clusters.

Black (1976) attempts to explain volatility by looking at the causal relations among stock returns, volatility changes, and related variables. According to him, negative shocks to returns increase financial leverage (Debt/Equity Ratio), making stocks riskier. This increased leverage will impact positively on the

[7] Who proposed Autoregressive Conditional Heteroschedasticity (ARCH) and Generalized Autoregressive Conditional Heteroschedasticity (GARCH) process for volatility clustering respectively.

volatility of the stock. Christie (1982) documents that volatility is an increasing function of financial leverage[8]. This can cause a negative relation between value of equity and elasticity of volatility. French, Schwert and Stambaugh (1987) extend the leverage effect to the market level. Their study examines the relationship between stock returns and stock market volatility in NYSE between 1982 and 1984 using the GARCH-in-mean model. They find that the expected risk premium on common stocks is positively related to the predictable level of volatility[9]. Additionally, Cheung and Ng (1992) investigate empirically the cross sectional and temporal relations between stock price dynamics and firm size. They find that unexpected negative stock returns tend to have a larger impact on future conditional stock volatility than unexpected positive stock returns. Furthermore, the impact of shocks on volatility varies inversely with firm size which is consistent with Black (1976) and Christie (1982)[10].

Shiller (1981b) performs variance bounds tests to dictate excess volatility by comparing the volatility of actual price index and perfect foresight price[11]. The variance bounds test demonstrates substantially larger volatility of the actual price series compared to perfect foresight price series. LeRoy and Porter (1981) provide similar tests. However, the variance inequality test was grossly violated and these two papers were heavily criticized in terms of the small sample biases and non-stationary process of dividend by Flavin (1983), Marsh and Merton (1986), and Kleidon (1986).

[8] Christie (1982) investigates the effect of several explanatory variables such as financial leverage, operating leverage, asset mix, and dividend, on the variance of equity returns.

[9] In other words, unpredictable volatility and returns are negatively related, thus they conclude that unexpected stock market returns are negatively related to the unexpected volatility of the stock returns.

[10] Black(1976) and Christie (1982) note that smaller firms are more inclined to experience a greater increase in their stock volatility and the impact of shocks on prices of small firms is more uncertain hence larger volatility.

[11] Actual price : de-trended by a long run exponential growth factor, perfect foresight price: it is constructed with the present discounted value of the actual subsequent real dividends

Chapter three discusses comprehensive studies and arising issues from the early 1990’s which related to stock market volatility and spillover effects. The prior literature on volatility risk is large, but almost all of it focuses on price and return volatility. Thus, it emphasizes the dimension of our study, namely, liquidity volatility and spillover effects among international stock markets.

2.6 FINANCIAL DEVELOPMENT AND ECONOMIC DEVELOPMENT

In neo-classical growth models, the long-run rate of growth is exogenously determined by either the savings rate or the rate of technical progress. The models emphasise that the dynamic process leads the economy to steady-state equilibrium in which per capita real output growth would eventually cease. However, in the endogenous growth theory, Lucas (1988) and Rebelo (1991) argue that the marginal productivity of capital does not converge to zero because a steady state growth depends on the level of accumulation of capital (both physical and human). Thus, even without exogenous factors (saving and technical innovation), endogenous growth is possible. For instance, investment in human capital, innovation and knowledge are significant contributors to economic growth. This shifting of interest could lead to stressing the role of financial development in economic growth. Financial development is usually defined as a process that marks improvements in the quantity, quality and efficiency of financial intermediary services. However, the relationship between financial development and economic growth is an ambiguous issue. For instance, Shaw (1973) and King and Levine (1993b) consider finance as an important driver of economic growth, while Robinson (1952) and Lucas (1988) argue that it is only a minor factor and that the role of finance has been overstressed. This section addresses contentious issues surrounding the application of the role of financial development in economic growth that is related to the last topic of this thesis.

2.6.1 THE EFFECTS OF FINANCIAL DEVELOPMENT

Most of the empirical studies give evidence of a positive relationship between financial development and economic growth. The empirical studies by Goldsmith (1969) assume that there is a positive correlation between the sizes of financial systems and the supply and quality of financial services. The study uses data for 35 countries over the period 1860-1963. The study finds that financial intermediary size relative to the size of the economy rises as countries develop. He also documents a positive correlation between financial development and economic growth. However, the model is unable to draw causal interpretations from the study's graphical representations and does not come to a conclusion about whether financial development causes growth. Moreover, it cannot examine cross-country evidence of the relationship between financial structure and economic growth because of the limitations of the data.

King and Levine (1993b) extend Goldsmith's work examining 77 countries over the period 1960-1980. They use four financial development indicators: DEPTH equals liquid liabilities of the financial system divided by GDP; BANK measures the relative degree to which the central bank and commercial banks allocate credit; PRIVATE is the ratio of claims on the non-financial private sector to domestic credit; and PRIV/Y is measured as gross claims on the private sector to GDP. They examine the relationship between these four financial indicators and four growth indicators: real per capita GDP growth; real per capita capital stock growth rate; total productivity growth; and ratio of investment to GDP. They find that there is a strong positive relationship between each of the financial development indicators and long-run growth.

Evaluating firms, managers and market conditions requires large costs for making investment decisions. Especially for individual savers, collecting and producing information on possible investments is not easy. Financial intermediaries, however, may produce better information on firms and reduce the costs of producing information; it could then result in improving resource allocation (Boyd and Prescott, 1986). Greenwood and Jovanovic (1990) examine dynamic interactions between financial intermediaries and economic growth. In this model, the capital is assumed to be scarce; there are also two types of shock such as aggregate shocks and project specific shocks. Financial intermediaries hold large portfolios as well as information about portfolios. Thus, they are able to recognise aggregate and specific shocks. Therefore, investors could have a better opportunity to choose higher profitable investments. This higher rate of savings transferred through intermediaries leads to the efficient allocation of capital, and the higher productivity of capital leads to higher growth.

Ehrlich, Gallais-Hamonno, Liu and Lutter (1994) suggest that stock markets offer useful business information that is important for the generation of human capital and for specific knowledge of companies. They demonstrate that investors do their best to obtain relative information on listed firms on a daily basis in order to gain the best returns in the markets. They trade based on the information, and the aggregate information becomes publicly available. This is the way in which investors get information and make current decisions and future plans. At the same time, entrepreneurs learn from the information produced by the stock markets and put it into practice at a company level. This becomes entrepreneurs’ human capital or companies' specific knowledge. Productivity growth is also enhanced by the accumulation of companies' specific knowledge. The other important aspect of the stock market is a price process. According to Stiglitz (1985), information is revealed in stock markets though publicly-posted prices. This could reduce the use of resources to acquire information because information can be obtained through the observation of process. For instance, when agents receive optimistic signals about a firm, they buy its shares and bid up its stock price. The high stock price in turn indicates that investors collectively believe the firm to have good prospects.

2.6.2 ROLE OF STOCK MARKET IN ECONOMIC GROWTH

Besides the issue of the role of financial development in economic growth, many studies have focused on the importance of bank-based systems. Stiglitz (1985) and Bhide (1993) argue that banks are superior to stock markets in improving resource allocation and corporate governance. Also, Shleifer and Vishny (1997) argue that markets do not effectively monitor managers because investors are often not interested in shareholders' returns; instead, they are interested in their own returns because of the separation of brains and capital. Moreover, bank-based systems can gather perfect information about firms. For instance, banks can make investments without revealing their investment decisions to the public. This can give incentives for them to research firms, managers and market conditions. Boyd and Prescott (1986) support this point and emphasise that banks can reduce information frictions and improve resource allocation. In sum, bank-based systems argue that there are limitations for market-based systems because they tend to have difficulty acquiring information about firms and monitoring managers, while bank-based systems do not suffer from the same fundamental limitations as markets.

However, a great deal of theoretical literature exists on the link between stock markets and economic growth. It suggests that stock markets may cause long-run growth by encouraging information acquisition, reducing the cost of mobilising savings and facilitating investment (Diamond, 1984; Greenwood and Jovanovic, 1990; Greenwood and Smith, 1997). Svaleryd and Vlachos (2005) argue that a well-functioning stock market can aggregate information about firms and markets in a better way than a single bank can. Also, stock markets may provide more attractive high-risk projects to enable individual investors to diversify risks. Levine (2005) shows that they need better risk management tools to raise capital in developed economies. Thus, stock markets can deliver benefits from market-based activities by providing better risk management and flexibility. Additionally, Beck and Levine (2002) emphasise that it is difficult to evaluate whether economic growth is caused by bank development or stock market development. Thus, the bank and market affect economic growth separately.

Regarding the debates on the relationship between stock market development and economic growth, it is necessary to discuss economic growth with the liquidity issues of stock markets because the shortage of liquidity resulted in the financial crisis in 2008.

2.6.3 LIQUIDITY AND ECONOMIC GROWTH

Liquid equity markets reduce the risk of investment and make it more attractive because they permit savers to obtain asset equity and to sell it rapidly and inexpensively. Firms also have permanent access to capital raised through equity issues and can carry out a transaction with lower cost. Since savers prefer to hold their savings under their own control, a liquid stock market or other financial institutions are essentially required for high-return projects and long-term investment. Thus, high-return projects and long-term investment could help economic growth, which is facilitated by enhanced liquidity.

Bencivenga, Bruce, and Starr (1996) demonstrate a model emphasising that accommodating investors' demand for liquidity is an essential function of financial markets. The model shows that there are ambiguous liquidity impacts on economic growth at the different degrees of reduction in transaction costs. If reduction of transaction costs is sufficiently large, enhanced liquidity leads to a higher level of the capital stock and national income. The model also implies that improvements in the financial market increase production and capital accumulation. Similarly, Diamond (1996) and Fulghieri and Rovelli (1998) show that firms have permanent use of the capital raised by issuing equities while savers have liquid assets in the form of these equities. In the liquid market, equity holders can easily sell their shares, and companies retain permanent access to the capital initially invested. Thus, initial investors can be assured of retaining access to their savings while the investment project is ongoing because they can sell their shares in the company quickly and at low cost. Levine and Zervos (1998) investigate the relationship between financial development and economic growth, but they examine the impact of stock market development and bank development on economic growth separately because banks provide different services to stock markets. In more detail, they investigate whether measures of stock market liquidity, size, volatility and integration with world capital markets are significantly correlated with current and future rates of economic growth, capital accumulation, productivity improvements and saving rates. The variables used in this study are bank development (bank credit to the private sector as a share of GDP), stock market development (market capitalisation relative to GDP), stock market activity (the value of trades relative to GDP) and market liquidity (the value of trades relative to market capitalisation). Also, they use additional measures such as stock market liquidity (turnover), stock volatility and two measures of stock market integration in world capital markets. The findings show evidence of an important empirical relationship between stock markets and economic growth. Furthermore, stock market liquidity and bank development are positively and significantly correlated with current and future rates of economic growth, capital accumulation and productivity growth, even after controlling for economic and political factors.

2.6.4 DEBATE IN THE LITERATURE

The conventional wisdom that posits the financial development is an important contributor to economic growth. However, some empirical studies argue that it is certainly not all cases and the contribution associated with financial development to economic growth is varying across countries. Fase (2001) investigates the relationship between financial development and long-term economic growth in the Netherlands between 1900 and 2000. The causality runs from financial intermediation to economic growth until World War II in the Netherlands, and vanishes afterwards. The study argues that the development of the financial system has a greater impact on growth in a developing country than in developed economies. Also, Neusser and Kugler (1998) investigate the hypothesis that development of the financial sector is essential for economic growth. They state that the causal relationship varies widely across countries and point out the importance of historical and institutional factors. Andres, Hernando and Salido (2004) performed Granger-causality tests among inflation, growth and banking system development using both cross section and time-series data over the period of 1961-1993 for a sample of OECD countries. They find that the link between finance development and growth is less reliable. Additionally, Arestis and Demetriades (1997) use time-series analysis and Johansen uses co-integration tests for the US and Germany. In Germany, they observed that banking development affects growth, while they could not find strong evidence for the US. However, Levine (1999) and Levine, Loayza and Beck (2000) examine how the legal environment affects financial development and how this effect is linked to long-term economic growth. Levine, Loayza and Beck (2000) examine 71 countries over the period 1960-1995 and find a strong link between financial development and growth that is not due to the country-specific legal system. Moreover, there is another strand to dispute the view that financial development positively affects growth. De Gregorio and Guidotti (1995) argue that financial development significantly reduces economic growth for countries in Latin America during a period of high inflation. This suggests that financial reforms or financial development requires a sufficiently low rate of inflation. Boyd, Levine, and Smith (2001) also argue that high inflation adversely affects the operations of financial markets. Their findings indicate that there is a significant negative relationship between inflation and both banking sector development and equity market activity.

Cross-sectional regressions are averaged over countries and cannot give country-specific details. Thus, findings are not clear on the causality issues. Hondroyiannis, Lolos, and Papapetrou (2005) empirically investigate the relationship between economic performance and the development of the banking system and the stock market in Greece over the period 1986-1999. The findings suggest the existence of bi-directional causality between finance and growth in the long run. The results show that bank and stock market financing promote economic growth in the long run, and that the contribution of stock market finance to economic growth appears to be substantially smaller compared to bank finance. Christopoulos and Tsionas (2004) examine the long-run relationship between financial depth and economic growth for 10 developing countries (Colombia, Paraguay, Peru, Mexico, Ecuador, Honduras, Kenya, Thailand, the Dominican Republic and Jamaica) over the period 1970-2000. They find that there is strong evidence in favour of the hypothesis that long-run causality runs from financial development to growth, but there is no evidence of bi-directional causality. The empirical evidence also suggests that there is no short-run causality between financial deepening and output.

Although many empirical studies have investigated the relationship between financial development and economic growth, the results are ambiguous, especially in comparison among international markets. Most of the empirical studies examine the relationship through cross-sectional data analysis, in which the results may vary considerably across countries due to differences in their institutional characteristics and in their legal, political and financial systems.

Moreover, cross-sectional data analysis does not permit the investigation of the direction and intensity of causal links and cannot settle the issue of causality.

CHAPTER 3: LIQUIDITY VOLATILITY AND SPILLOVER EFFECT

3.1 INTRODUCTION

As a branch of finance, market microstructure takes into account market frictions and trading costs to explore the link between market organization and market quality such as efficiency, liquidity and volatility. This empirical study focuses on two dimensions of market quality, namely, liquidity and volatility in order to investigate liquidity spillover effects. According to the European Economy (2008), the degree of international market integration has been increased gradually. The report analyses the market integration between three regions such as North America, Europe and Asia. It shows that the integration between Europe and Asia is lower than the regions between Europe and North America and between Asia and North America. Since the spillover effect between markets is highly related to the degree of market integration, it could expect a significant spillover effect between North America and Europe and between North America and Asia. Thus, it is necessary to investigate the existence of spillover effects between less integrated markets, specifically, between Europe (the UK) and Asia (Japan, Korea, China, and Hong Kong). The study also includes the US in this study because it is the biggest and the most liquid stock market in the world.

Market microstructure literature, especially commonality in liquidity, has attracted a lot of attention (Chordia, Roll, and Subrahmanyam (2000), Huberman and Halka (2001), Galariotis and Giouvris (2007, 2009), Galariotis and Giouvris

(2008)). Since the risk level of each market depends on liquidity, investors may use liquidity information as an important indicator to form their portfolios. Therefore, it could increase the degree of liquidity commonality due to the correlated trading which stems from various channels such as institutional investments, trade and financial linkages, the inter-banking system. Various researchers documented the relationship between individual liquidity and market wide liquidity and find common market-wide factors[12]. While these studies focus on single markets, Chordia, Sarkar and Subrahmanyam (2005) examine the dependence of liquidity between different markets and show that shocks to liquidity in one market can have an impact on the liquidity in another market[13].

Since the subprime crisis in 2007, market microstructure focuses on the importance of commonality in liquidity in international stock markets. Several studies emphasize that increases in cross country correlation is consistent with capital market integration[14] and commonality in liquidity is increasing during extreme market conditions and it spills over to other markets[15]. Frank, Hermosillo, and Hesse (2008) point out the importance of interconnected financial markets and Nicolo and Ivaschenko, (2008) emphasize various channels through which shocks can turn into serious market contagion. These various channels (asymmetric information, trade and financial linkages, inter-banking systems, institutional investors and indexation) might be the main vehicle which spreads shocks worldwide and it causes co-movements in stock liquidity.

[12] Chordia, Roll and Subrahmanaym (2000) look into common factors in the US market. Galariotis & Giouvris (2007, 2008) look into the UK market while Galariotis & Giouvris (2008) look into the Athens Stock Exchange. Huberman and Halka (2001), Hasbrouck and Seppi (2001) provide similar conclusions.

[13] Tang and Yan (2006) find significant liquidity spillovers from bond, stock and option markets to the CDS market. Subrahmanyam (2007) extends the study to cover liquidity, returns and order flow between the equity market and the real estate investment trusts.

[14] See Longin and Solnik (1995). They argue that increased capital market integration goes hand-in-hand with increased cross-county correlation

[15] Hameed, Kang, and Viswanathan (2006) show that market declines affect both liquidity and liquidity commonality. After large and negative market returns, commonality in liquidity increases and peaks with liquidity crisis and illiquidity in one industry spillovers to the other industry.

Other important dimensions in market microstructure are volatility and spillovers. Several authors emphasize that the stock price does not always reflect fundamentals but fluctuations due to incoming news which is often seen as price volatility. For instance, Eun and Shim (1989) examine volatility and show that it transmits across international stock markets[16]. Jang and Sul (2002); Caporale, Pittis, and Spagnolo (2006) suggest that extreme price changes can transmit through volatility spillovers. Hamao, Masulis and Ng (1990) examined volatility spillover effects between New York, Tokyo, and London stock markets using the GARCH-M model. They confirmed that there is a significant spillover effect from London and New York to Tokyo but not the other way around. Also Engle, Ito and Lin (1990) investigate intraday volatility spillover between the US and Japanese foreign exchange market using a multivariate GARCH model[17]. They find that news which is revealed when one foreign exchange market is open contributes to the return volatility of the next market to open.

While all of these papers analyse the spillover effect between stock returns and volatility, academic research on spillover effects associated with liquidity, however, is rather limited. The first attempt testing dependence of liquidity between U.S. equity and bond market have been made by Chordia, Sarkar and Subrahmanyam (2005). They use a vector autoregressive model and find that return volatility shocks predict an increase in bond liquidity. Also, Chordia, Sarkar and Subrahmanyam (2006), emphasize that shocks to liquidity in one market have a spillover effect across different sectors of stock markets. They

[16] Eun and Shim (1989) analyze international stock market interdependence by using VAR and documented the existence of substantial interdependence among national stock markets.

[17] See more of empirical studies for spillover effects: French, Schwert, and Stambauge (1987), Nelson (1991), Lin, Engle, and Ito (1994), Karolyi (1995), Koutmos and Booth (1995), De Santis and Imrohoroglu (1997), Ng (2000), In, Kim, Yoon, and Viney (2001), Worthington and Higgs (2004). These studies investigate relationships between stock returns and volatility.

show that liquidity innovations in either the large or small cap sector are informative in predicting liquidity. Chen and Poon (2007) report that stock market downturn Granger causes illiquidity while illiquidity does not Granger causes market downturn. Furthermore, Chan, Jain, and Xia (2005) investigate closed end country fund and show that illiquidity in one market can easily spillover to another and affect both the funds share price and its asset. Tang and Yan (2006) analyse liquidity spillovers to credit default swap (CDS) markets. They find a significant liquidity spillover effect from bond, stock, option markets to the CDS market.

Unlike the study by Tang and Yan (2006) and other studies mentioned previously, this study concentrates on liquidity volatility spillovers in cross-country level. To the best of my knowledge, this chapter is the first empirical study of liquidity volatility spillovers in international stock markets adopting GARCH-M model. The main purpose of this study is two-fold. First, it investigates the aggregate stock market liquidity and level of volatility. Second, it examines the existence of spillover effect between international markets. This study focuses mainly on cross-country and time series properties of market-wide liquidity. Liquidity is measured as the aggregate of individual bid-ask spread. Although, the global economy and the world trading system have changed significantly since 1994[18], a large body of literature is focused on the relationship between the US and other countries, especially, when it looks at spillover effects associated with liquidity shocks. The study investigates if there are any liquidity volatility spillover effects between UK and East Asian countries (Japan, Hong Kong, Korea, and China) and it also includes the US. It uses the following stock

[18] Please see the report of 17th APEC Ministerial meeting, Busan, Korea 15-16 November 2005 (http://www.mofa.go.jp/policy/economy/apec/2005/bogor.pdf).

indexes: FTSE100, S&P 100, NIKKEI 225, Hang Seng, KOSPI 100, and Shen Zhen 100. It presents a statistically significant liquidity volatility spillover effect between the UK and East Asian countries. Additionally, there are strong liquidity volatility spillover effects between the UK and the US. This study confirms that changes in liquidity volatility in one market have a positive impact on the other market's liquidity volatility.

The rest of the chapter is organized as follows. Section 3.2 discusses previous studies in the literature. Section 3.3 presents the data set and preliminary analysis of the two liquidity proxies for the six countries. Adopted methodology is presented in section 3.4 and section 3.5 discusses empirical results. Section 3.6 reports robustness tests. Finally, it concludes in section 3.7.

3.2 LITERATURE REVIEW

Rational expectations and the Efficient Market Hypothesis (EMH) often fail to explain the behaviour of extreme changes in stock prices because stock prices do not reflect fundamentals all the time because it contains irrational investments. The stock price movement contains rational and irrational trading behaviour derived from incoming news. When the news is released, informed investors trade rationally based on the news while uninformed investors trade based on the price movement due to the lack of information or information asymmetry. This uninformed trading creates noise in share prices resulted in extreme changes in stock prices. This unexplained extreme price movement is often expressed as stock price volatility and the degree of volatility is different between emerging stock markets and mature markets. De Santis and Imrohoroglu (1997) found evidence of time-varying volatility and show that the emerging stock markets are more volatile than developed stock markets. Moreover, different level of volatility in international stock markets is correlated with each other due to capital market liberalization which increases the relation between developed markets and emerging markets.

3.2.1 VOLATILITY SPILLOVER EFFECT ON STOCK RETURNS (Case A in Panel 1 of Figure 3.1)

After the stock market crash (October 19, 1987), interest in volatility spillover across international equity markets intensified and perpetuated a great effort to identify the relation between stock markets risk (conditional variance) and its expected return (conditional mean). Schwert (1990) analyzed the market crash event in 1987 and remarked that this financial crisis was followed by a short period of extreme level of volatility. In the financial literature, the interdependence of volatility in international markets has been widely studied. Hamao, Masulis, and Ng (1990) introduced the first paper examining volatility spillover effect between New York, Tokyo, and London stock market using GARCH-M model. They report that there is significant spillover effect from the U.S. market and the U.K. market to the Japanese market while there is no significant spillover effect from Tokyo stock market to the London and the New York markets. However, it has been argued that the volatility spillover effect is due to the overlapping trading hours between the U.S and the U.K.

Karolyi (1995) adopts the M-GARCH model for testing the international transmission of stock returns and volatility between the U.S. and Canada reporting that stock returns' volatility in one market has an impact not only on conditional market returns but also on the conditional market volatility of the other market. Furthermore, Nelson (1991) develops the E-GARCH model in an attempt to capture the asymmetric impact of shocks on volatility and confirmed that an increase in volatility is caused by negative innovations rather than positive innovations. Koutmos and Booth (1995) support Nelson's findings by applying the model for New York, London, and Tokyo[19].

In Asian markets context, De Santis and Imrohoroglu (1997) analyzed 15 emerging markets in terms of dynamics of expected stock returns and volatility and found that emerging markets are characterized by a higher and persistent volatility compared to the developed markets both at the conditional and unconditional level. After the Asian crisis in 1997, financial economists have been focusing on stock market interdependence within the Asian markets. The stock market interdependence and volatility in the Asian stock market during the Asian crisis is firstly investigated by In, Kim, Yoon, and Viney (2001). They find that the Korean market plays a lesser role as an information producer and Hong Kong plays an important role in the transmission of volatility to other Asian markets. However, Chancharoenchai and Dibooglu (2006) argue that the sudden fallout in Thailand seems to have played an important role. The crisis started in Thailand and then spread to other financial markets. Jang and Sul (2002), and Leong and Felmingham (2003) emphasize that the co-movement and causal relationship between Asian stock markets is getting stronger during the crisis.

[19] Volatility associated with the bad news in New York is transmitted to Tokyo and London in the next trading day and from Tokyo to London. This suggests that the transmission of volatility is asymmetric and negative innovations in foreign markets increase volatility the next day more than positive innovations in foreign markets.

3.2.2 LIQUIDITY VOLATILITY AND SPILLOVER EFFECT (case B & C in panel 1 of figure 3.1)

Bernardo and Welch (2003) argue that the market making sector is risk averse and it cannot expand liquidity instantly[20]. Thus, they emphasize investors' fear of future illiquidity as an important driving force of financial crisis. This study, however, could not explain how the market risk spreads across financial markets and institutions. Recently, market microstructure models find that the return volatility is a crucial factor in driving market illiquidity and identified the positive relationship between illiquidity and return volatility [Chordia, Sarkar, and Subrahmanyam (2005), Deuskar (2006), and Chen and Poon (2007)]. The first attempt to test if there is any dependence in liquidity between the US equity and bond market have been made by Chordia, Sarkar and Subrahmanyam (2005). They used a vector autoregressive model and found that shocks to liquidity in one market have an impact on the liquidity in the other market. More importantly, they find that liquidity and volatility shocks are positively correlated across stock and bond markets. Furthermore, Chordia, Sarkar and Subrahmanyam (2006) investigate persistent liquidity spillovers across different sectors of the stock market. They find that the liquidity innovations in either the large or small cap sector are informative in predicting liquidity and large cap stocks lead small cap in directional price moves, but small caps lead large caps in the discovery of volatility. Angelidis and Andrikopoulos (2010) investigate the London Stock Exchange and they show a significant return-volatility spillover effect as well as liquidity spillover effect from large cap stocks to small cap stocks. Also they find that shocks in illiquidity can predict shocks in return volatility. Moreover, Tang

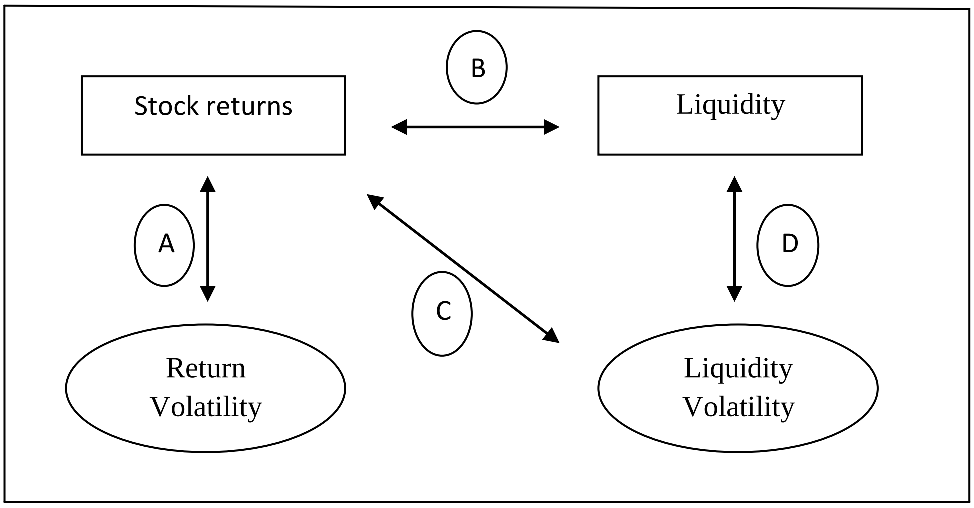
[20] With small changes in liquidation, it could cause a financial market run in which prices can fall due to the investors' fear.

and Yan (2006) show that illiquidity of other markets such as bond markets and stock markets spill over to the CDS market.

All previous studies discussed concentrated on 1) stocks returns and volatility 2) liquidity and stock returns and 3) liquidity volatility and market returns. The study on the other hand concentrates on liquidity volatility and spillover between the UK and selected Asian markets.

Figure 3.1: Spillover Effect

Panel1: Various Dimensions of Spillovers



Panel 2: Summary of Findings from Various Dimensions
A: Relationship between stock returns and volatility: numerous empirical studies have been conducted to investigate the relationship between stock returns and volatility and the finding is controversial. Positive relationship between returns and volatility: French et al. (1987), Theodossiou and Lee (1995), Lee et al. (2001), Chou (1988), Campbell and Hentschel (2003), Bansal and Lundblad (2002). Negative relationship between returns and volatility: Baillie and DeGennaro (1990), Nelson (1991), Glosten and Jagannathan and Runkle (1993), Whitelaw (2000).
B: Relationship between liquidity and stock returns: the findings in the literature show conflicting results. Positive relationship between liquidity and returns: Amihud and Mendelson (1986), Eleswarapu (1998), Martinez, Nieto, Rubio, and Tapia (2005) Negative relationship between liquidity and returns: Chordia et al. (2001) Pastor and Stambaugh (2003), Marshall and Young (2003), Moore and Sadka (2006).
C: Relationship between liquidity volatility and market returns: market microstructure investigates stock markets emphasizing a positive and significant relation between expected return and its volatility of liquidity. Positive relationship between liquidity volatility and returns: Brennan and Subrahmanyam (1996), Brennan, Chordia and Subrahmanyam (1998), Amihud (2002), Chordia, Huh, and Subrahmanyam (2009).
D: relationship between liquidity and liquidity volatility: It has not been studied extensively yet. Tang and Yan (2006) analyse liquidity spillovers (case of D) to credit default swap (CDS) markets. They find significant liquidity spillovers from bond, stock, option markets to the CDS market. This paper is mainly dealing with liquidity spillovers but not volatility spillover effect.

3.3. DATA AND PRELIMINARY ANALYSIS

3.3.1 DATA SAMPLING

This chapter examines the daily stock liquidity volatility and spillover effects across Asian markets and the UK and the US market is included. The sample period is from 10/04/2006 until 15/03/2010 because the US data starts from 10/04/2006. The study uses Daily Average Absolute Bid-Ask Spread (ABS) and Daily Average Proportional Bid-Ask Spread (PRO) as a proxy of liquidity for the 6 countries namely UK (FTSE100), US (S&P100), Japan (NIKKEI225), Hong Kong (Hang Seng), China (Shen Zhen100), and Korea (KOSPI100). All the data used in this paper is obtained from DATASTREAM. Regarding Daily Average Absolute Bid-Ask Spread, Construction of this liquidity proxy as follows: it takes the difference between ask and bid price for each stock and then the spread is averaged over the day. Regarding the second liquidity variable, Daily Average Proportional Bid-Ask Spread is estimated as: Absolute Spread/mid-quote where mid-quote is equal to (bid-price+ask-price)/2. All proxies are expressed in British pounds.

This empirical study uses a total of 1026 observations in the sample period which is based on Monday to Friday trading but it has been reduced due to non-trading days. Although, NIKKEI is trading on Saturday it excluded in order to synchronize trading days with FTSE100. Hence, the sample of FTSE100 is reduced to 992 daily observations, S&P100 (989 observations), NIKKEI225 (964 observations), KOSPI100 (976 observations), Hang Seng (971 observations) and finally, China has the biggest reduction in total observations with 957 observations in total. The different changes in total observations for each market are due to the different holidays and no trading days for each country. For instance, countries in the sample have different non trading days which are 34 days for the UK, 37days for the US, 62 days for Japan, 55 days for Hong Kong, 69 days for China and 51days for Korea. Since the main aim is investigating the inter-relationship between the UK and East-Asian markets and of course the U.S. it needs to adjust the data set which further reduces the number of total observations. For the UK and US, it obtain 971 trading days after synchronizing the two markets' time series data set; for UK and Japan (932 days), for UK and Hong Kong (959 days), for UK and China (924 days), and for UK and Korea (952 days).

Figure 3.2: Exchange Trading Hours

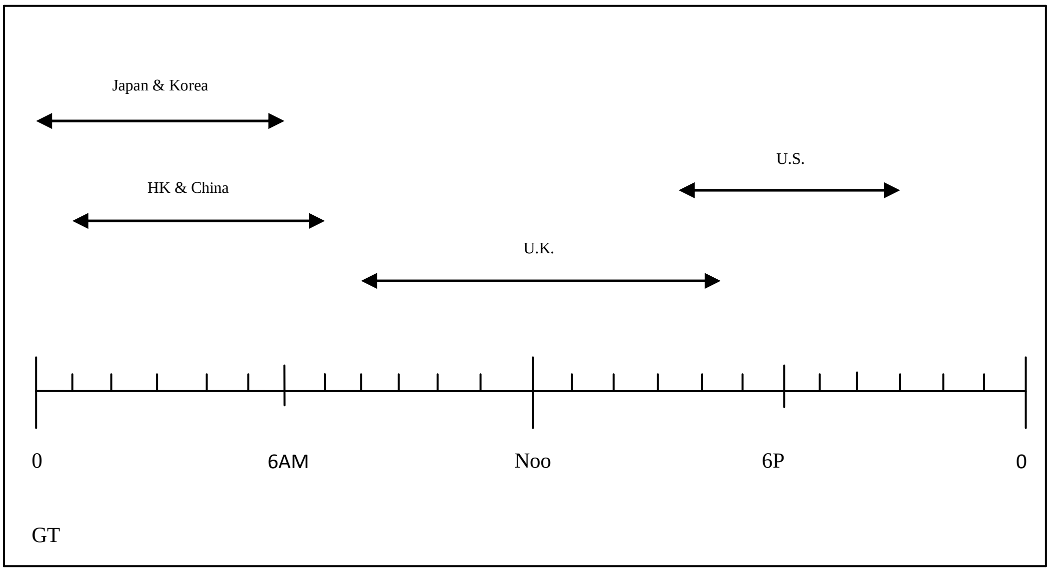


Figure.3.2 shows the trading hours of the six exchanges in Greenwich Mean Time. The opening hours in New York, represent late afternoon trading in London. East Asian markets open earlier than London and New York. The study investigates the relationship between the UK-US and UK-Asian markets. In order to examine the interactive spillover effect between US and Asian markets the data

set requires further exclusion of non-trading days which causes non-stationarity. Estimating the regression model with non-stationary data could cause inconsistent results because standard errors and test statistics estimated with non-stationary data are invalid[21]. Therefore, this study does not examine trading between US-East Asian Countries.

The study uses the close-to-close daily spread because the opening ask and bid price are not available. As this study uses the close-to-close price, changes in Asian markets could contain the information from the US. The information generated during overnight is incorporated in the bid-ask price of Asian markets, thus it possibly expects strong liquidity spillover effects between the UK and Asian countries.

3.3.2 PRELIMINARY ANALYSIS

This section presents some basic statistical tests such as stationarity tests, descriptive statistics and autocorrelation tests for the two spread proxies.

Stationarity of the data set is crucial for regression analysis. If non-stationarity is present, the series may increase or decrease over time which causes major problems with regression results such as biasedness of the standard errors. In order to test for stationarity, it estimates two unit root tests namely and Phillips-Perron (PP) test and Augmented Dickey Fuller (ADF) test.

[21] Non-stationary time series is caused by random walk with or without a drift and deterministic trends in the series. In other words, it does not have a constant long-term mean and a constant variance independent of time. Thus, non-stationary data is unpredictable and cannot be modelled or forecasted because it has a variable variance and a mean that does not remain near, or returns to a long-run mean over time. Also, holiday schedules in China, Hong Kong, and Korea are varying in each year due to the lunar calendar system. This could cause non-stationary time series.

Table 3.1 shows the unit root test of Daily Absolute Spread and Daily Proportional Spread using the ADF and the PP test. The hypothesis of a unit root is rejected. For FTSE100, S&P100, Hang Seng, Shen Zhen, and KOSPI100, t-statistics are statistically significant at 1% and NIKKEI225 is statistically significant at 5% level.

Table 3.1: Unit root tests

	ADF TEST		PP TEST	
	Absolute T-statistics (prob)	Proportional T-statistics (prob)	Absolute T-statistics (prob)	Proportional T-statistics (prob)
FTSE100	-4.803205 (0.0001)***	-3.500864 (0.0082)***	-19.36391 (0.0000)***	-22.85463 (0.0000)***
S&P100	-4.197356 (0.0007)***	-3.917735 (0.0020)***	-21.99787 (0.0000)***	-18.60531 (0.0000)***
NIKKEI225	-2.985596 (0.0366)**	-3.423661 (0.0104)**	-12.91880 (0.0000)***	-13.21208 (0.0000)***
Hang Seng	-4.545316 (0.0002)***	-4.300339 (0.0005)***	-29.19484 (0.0000)***	-20.72770 (0.0000)***
Shen Zhen	-3.349371 (0.0131)**	-26.93852 (0.0000)***	-21.86107 (0.0000)***	-27.62516 (0.0000)***
KOSPI100	-5.399334 (0.0000)***	-5.837596 (0.0000)***	-29.66082 (0.0000)***	-27.31870 (0.0000)***

Note: The data set used in this test is adjusted the non-synchronous trading schedule. Null Hypothesis: H_0 : it has a unit root.. *, **, *** indicate statistically significant at 10%, 5%, and 1% respectively.

Table 3.2 reports several descriptive statistics for the two spread proxies which are daily average absolute bid ask spread (ABS) and daily average proportional average bid ask spread (PRO). These include the mean, standard deviation, and skewness and kurtosis. Judging from the sample standard deviations for ABS, the UK is the most volatile market and the second most volatile market is Japan. Hong Kong shows the lowest level of liquidity volatility. When it looks at the preliminary statistics of PRO, the Chinese market is the most volatile and the second most volatile stock exchange is the Japanese market and for the rest of countries, the level of volatility is as follows (from highest to lowest): US, Hong Kong, UK, and Korea.

Table 3.2: Preliminary Statistics on Daily Stock Market Liquidity

Daily Absolute Average Bid Ask Spread					
Countries	Mean	Standard deviation	Skewness (m_3)	Kurtosis(m_4)	JB
U.K.	1.267089	0.534272	2.018123	13.52011	5131.440 (0.0000)*
U.S.	0.025782	0.014042	2.578641	12.14988	4458.681 (0.0000)*
Japan	0.324934	0.117205	0.516946	2.735621	44.22449 (0.0000)*
Hong Kong	0.005883	0.001725	1.038931	4.951686	321.6775 (0.0000)*
China	0.001312	0.000652	5.824301	65.87869	157442.7 (0.0000)*
Korea	0.205541	0.065668	1.123616	4.483123	36895.52 (0.0000)*
Daily Proportional Average Bid Ask Spread					
Countries	Mean	Standard deviation	Skewness (m_3)	Kurtosis(m_4)	JB
U.K.	0.001740	0.000803	3.421345	33.06842	38433.51 (0.0000)*
U.S.	0.001194	0.000881	6.281518	63.06749	151421.9 (0.0000)*
Japan	2.02e-05	9.32e-06	1.625117	5.875316	731.2884 (0.0000)*
Hong Kong	0.000215	8.20e-05	2.244138	10.84477	3233.367 (0.0000)*
China	0.001426	0.005230	5.922980	42.76489	66495.75 (0.0000)*
Korea	0.003089	0.000651	4.835318	50.78938	93905.17 (0.0000)*

JB is the Ljung-Box Q-statistics and P-values are in parentheses. * indicates statistically significant at 5% level.

Clark (1973) and Blattberg and Gonedes (1974) documented that the unconditional distribution of financial returns exhibits fat tails and excess peakedness at the mean indicating that the returns series does not follow the normal distribution. Similarly, French and Roll (1986) and Bollerslev (1986) state that accumulation of information occurs during the market closing time which is reflected in prices when the markets reopen which creates daily seasonality. This phenomenon leads to a jump in stock prices and returns most of the time series are not normally distributed.

The statistics m_3 and m_4 are the standard measures of skewness and kurtosis, respectively. Under the null hypothesis of normality for the liquidity series, m_3 and m_4 are asymptotically distributed as m_3~N(0,6/T) and m_4~N(3,24/T), where

T is the number of observations. In table 3.2, the skewness of 2.018123 for the ABS in UK shows that the distribution is positively skewed relative to the normal distribution (0 for the normal distribution). All countries (both ABS and PRO) have positively skewed distribution which implies a non symmetric series. Kurtosis is much larger than 3 (the kurtosis for a normal distribution) for all countries. Therefore, none of the time series data is normally distributed. This positively skewed distribution implies that all countries have some experiences of high illiquidity but the liquidity level remains stable most of the time.

Table 3.3 presents the autocorrelation coefficients of absolute and proportional spread. Under the null hypothesis of serial independence, Q statistic follows the chi-squared distribution. The six countries' autocorrelation coefficients show persistence and are decaying very slowly. Also the coefficient and probability of the ADF test show a statistically significant result indicating the presence of serial correlation in the stock market liquidity series for both absolute and proportional spread. It performs ADF test for the two daily liquidity proxies (ABS and PRO) by running the following regressions:

$$ABS_t = C + ABS_{t-1} + ABS_{t-2} + \cdots + ABS_{t-v} + e_t$$

$$PRO_t = C + PRO_{t-1} + PRO_{t-2} + \cdots + PRO_{t-v} + e_t \qquad (3.1)$$

Using a different number of lags each time.

Table 3.3
Autocorrelation Coefficient for Daily Stock Liquidity

Panel A: (Daily average absolute bid ask spread)

ACF	U.K.	U.S.	Japan	Hong Kong	China	Korea
ρ(1)	0.698 (0.000)	0.584 (0.000)	0.797 (0.000)	0.476 (0.000)	0.582 (0.000)	0.290 (0.000)
ρ(2)	0.700 (0.000)	0.497 (0.000)	0.771 (0.000)	0.467 (0.000)	0.524 (0.000)	0.204 (0.000)
ρ(3)	0.750 (0.000)	0.512 (0.000)	0.759 (0.000)	0.485 (0.000)	0.524 (0.000)	0.219 (0.000)
ρ(4)	0.666 (0.000)	0.565 (0.000)	0.752 (0.000)	0.492 (0.000)	0.480 (0.000)	0.242 (0.000)
ρ(5)	0.664 (0.000)	0.450 (0.000)	0.726 (0.000)	0.484 (0.000)	0.471 (0.000)	0.230 (0.000)
ρ(6)	0.652 (0.000)	0.430 (0.000)	0.734 (0.000)	0.474 (0.000)	0.433 (0.000)	0.184 (0.000)
ρ(7)	0.647 (0.000)	0.540 (0.000)	0.719 (0.000)	0.419 (0.000)	0.483 (0.000)	0.275 (0.000)
ρ(8)	0.633 (0.000)	0.502 (0.000)	0.715 (0.000)	0.405 (0.000)	0.462 (0.000)	0.279 (0.000)
ρ(9)	0.634 (0.000)	0.433 (0.000)	0.711 (0.000)	0.462 (0.000)	0.461 (0.000)	0.215 (0.000)
ρ(10)	0.628 (0.000)	0.435 (0.000)	0.715 (0.000)	0.444 (0.000)	0.429 (0.000)	0.197 (0.000)

Note: Parentheses indicate probability.
$ABS_t = C + ABS_{t-1} + ABS_{t-2} + \cdots + ABS_{t-v} + e_t$
Estimating this regression with a different number of lags each time

Panel B: (Daily average proportional bid ask spread)

ACF	U.K.	U.S.	Japan	Hong Kong	China	Korea
ρ(1)	0.620 (0.000)	0.626 (0.000)	0.795 (0.000)	0.651 (0.000)	0.123 (0.000)	0.387 (0.000)
ρ(2)	0.631 (0.000)	0.529 (0.000)	0.759 (0.000)	0.623 (0.000)	0.079 (0.000)	0.331 (0.000)
ρ(3)	0.676 (0.000)	0.530 (0.000)	0.750 (0.000)	0.600 (0.000)	0.100 (0.000)	0.260 (0.000)
ρ(4)	0.587 (0.000)	0.568 (0.000)	0.739 (0.000)	0.576 (0.000)	0.049 (0.000)	0.309 (0.000)
ρ(5)	0.586 (0.000)	0.467 (0.000)	0.707 (0.000)	0.588 (0.000)	0.026 (0.000)	0.306 (0.000)
ρ(6)	0.574 (0.000)	0.439 (0.000)	0.718 (0.000)	0.582 (0.000)	-0.005 (0.000)	0.256 (0.000)
ρ(7)	0.610 (0.000)	0.583 (0.000)	0.684 (0.000)	0.547 (0.000)	0.087 (0.000)	0.317 (0.000)
ρ(8)	0.560 (0.000)	0.536 (0.000)	0.665 (0.000)	0.536 (0.000)	0.043 (0.000)	0.257 (0.000)
ρ(9)	0.559 (0.000)	0.460 (0.000)	0.669 (0.000)	0.551 (0.000)	0.007 (0.000)	0.269 (0.000)
ρ(10)	0.555 (0.000)	0.443 (0.000)	0.672 (0.000)	0.548 (0.000)	-0.022 (0.000)	0.231 (0.000)

Note: Parentheses indicate probability.
$PRO_t = C + PRO_{t-1} + PRO_{t-2} + \cdots + PRO_{t-v} + e_t$
The model estimates this regression with a different number of lags each time

3.3.3. OPTIMAL LAG STRUCTURE

In this part, the optimal lag-structure of ARMA (p,q) for each country is identified based on the Box-Jenkins methodology in order to filter out autoregressive and moving average effects from the sample before running the GARCH-M model. It detects the optimal lag of ARMA(p,q) for each country's two liquidity proxies by employing a number of different specifications namely autoregressive term only, moving average term only or a combination of the two. Due to the non-synchronous trading in each of the six countries, the optimal lag structure of ARMA is varying for each pair of countries. Table 3.4 summarizes the order of ARMA. Panel A presents results for ABS and panel B present results for PRO.

Table 3.4: Optimal Lag Structure of ARMA(p,q)

Panel A: Daily average absolute bid ask spread (ABS)

Group of country	countries	ARMA (p,q)	LM test
UK & US	UK	ARMA (3,6)	0.084945 (0.9584)
	US	ARMA (5,6)	0.597191 (0.7419)
UK & JAPAN	UK	ARMA (5,3)	3.694541 (0.1577)
	JAPAN	ARMA (4,3)	2.504358 (0.2858)
UK & H.K.	UK	ARMA (6,3)	0.043902 (0.9783)
	Hong Kong	ARMA (7,7)	0.086188 (0.7691)
UK & CHINA	UK	ARMA (3,4)	0.892660 (0.6400)
	CHINA	ARMA (4,6)	0.070238 (0.9655)
UK & KOREA	UK	ARMA (5,4)	0.818323 (0.6642)
	KOREA	ARMA (6,5)	1.336274 (0.5127)

Panel B: Daily average proportional bid ask spread (PRO)

Group of country	countries	ARMA (p,q)	LM test
UK & US	UK	ARMA (5,5)	2.658961 (0.2646)
	US	ARMA (7,7)	1.272822 (0.5292)
UK & JAPAN	UK	Non stationary	
	JAPAN	Non stationary	
UK & H.K.	UK	ARMA (2,5)	0.123777 (0.9400)
	Hong Kong	ARMA (5,5)	0.047876 (0.8268)
UK & CHINA	UK	ARMA (8,7)	6.063863 (0.0482)
	CHINA	ARMA (6,5)	2.026247 (0.3631)
UK & KOREA	UK	ARMA (6,6)	1.562503 (0.4578)
	KOREA	ARMA (3,2)	0.632652 (0.7288)

The best fitting model of ARMA(p,q) is based on Akaike information Criterion which is chosen as lowest value. LM test: the LM test statistic is asymptotically distributed as a $\chi^2(p)$. H_0 = No serial correlation up to lag order p, H_1 = serial correlation up to lag order p. Probability-value in Parentheses. UK(FTSE100), US(S&P100), JAPAN(NIKKEI225), HK(HangSeng), CHINA(ShenZhen100), and KOREA(KOSPI100) are being used.

For the UK &US group in Panel A, FTSE100 for the UK market is modelled as ARMA(3,6) and US is modelled as ARMA(5,6). NIKKEI225 for the Japanese stock market is best modelled as ARMA(4,3) model and Hong Kong as ARMA(7,7). China and Korea are modelled as ARMA(4,6) and ARMA(6,5) respectively. The LM-tests for all countries show that it does not reject H_0: No serial correlation.

In terms of proportional spread (Panel B), the order of ARMA parameter are (5,5), (7,7), (5,5), (6,5), and (3,2) for the UK, the US, HK, CHINA and KOREA respectively. The majority of the countries' LM tests show that there is no serial correlation after fitting ARMA except the UK in the UK-China group in which the null hypothesis is rejected. This implies that the UK market has a long memory of liquidity and decays slowly to zero. However, when the GARCH-M model is estimated for this group, ARCH-LM test shows that there is no serial correlation remaining for the UK.

3.4. METHODOLOGY

Autoregressive Conditional Heteroskedasticity (ARCH) models are specifically designed to model and forecast conditional variances. The variance of the dependent variable is modelled as a function of past values of the dependent variable and independent or exogenous variables. The ARCH models were introduced by Engle (1982) and generalized as GARCH (Generalized ARCH) by Bollerslev (1986) and Taylor (1986). These models are widely used in various branches of econometrics, especially, in financial time series analysis.

3.4.1 ADOPTED MODEL

In finance, the return of a security may depend on its volatility. To model such a phenomenon, one may consider introducing the conditional variance or standard deviation into the mean equation which is known as the GARCH-in-Mean (GARCH-M) model (Engle, Lilien and Robins, 1987):

$$Y_t = c + \delta_1 \sigma_t^2 + \epsilon_t, \quad \text{(Mean equation)} \tag{3.2}$$

$$\epsilon_t \,|\Omega_{t-1} \sim \text{N}(0,\sigma_t^2), \tag{3.3}$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad \text{(Variance equation)} \tag{3.4}$$

Where c is a constant, the parameter δ_1 is called the risk premium parameter. A positive δ_1 indicates that the return is positively related to volatility because the expected return on an asset is related to the expected asset risk thus the estimated coefficient on the expected risk is a measure of the risk-return trade-off. This model is for relations between stock returns and its volatility. In order to investigate the effect of volatility on liquidity and the spillover effect, this study follows the method introduced by Hamao, Masulis and Ng (1990). They use GARCH-M model to estimate return volatility and spillover effect between New York, London, and Tokyo stock exchange. In order to capture time varying volatility, they follow a MA(1)-GARCH(1,1)-M model. Investigation of the spillover effect is fulfilled by placing recent return volatility shocks which occurred in the foreign market into the variance equation denoted X_{t-1}. X_{t-1} is obtained from the MA(1)-GARCH(1,1)-M model applied to the previous foreign market. Unlike the previous study, this study uses ARMA(p,q)-GARCH(1,1)-M model employing two liquidity proxies (ABS and PRO). In order to build the model, it uses the Box-Jenkins method to remove serial correlation and moving average effects from the data set. The order of ARMA was based on the Akaike information criterion (1974).

In order to model liquidity volatility, following model is adopted:

$$L_t = c + ARMA(p,q) + \delta_1\sigma_t^2 + \delta_2 D_t + \delta_3\epsilon_{t-1} + \epsilon_t, \text{ (Mean equation)}$$

$$\sigma_t^2 = c + \alpha_1\epsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2, \text{ (Variance Equation)} \quad (3.5)$$

Where L_t denotes liquidity (ABS and PRO), and σ_t^2 in the variance equation represents the conditional variance of the stock liquidity at time t, and σ_t^2 in the mean equation is the liquidity premium parameter. D represents a dummy variable that takes a value of 1 on days following weekends and is 0 otherwise. In the variance equation, the volatility of liquidity in the market is obtained by the sum of $\alpha_1$and $\beta_1$which is expected to be less than 1. So the model converges to long term volatility.

At the later stage, it introduces an exogenous variable X_{t-1} into the conditional variance equation that captures the potential liquidity volatility spillover effect of another market. The model is given below:

$$L_t = c + ARMA(p,q) + \delta_1\sigma_t^2 + \delta_2 D_t + \delta_3\epsilon_{t-1} + \epsilon_t, \text{(Mean equation)}$$

$$\sigma_t^2 = c + \alpha_1\epsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 + \delta_4 X_{t-1} + \delta_5 D_t, \quad \text{(Variance equation)} \quad (3.6)$$

Where the specifications of model (3.6) are the same as model (3.5) except X_{t-1} which is the most recent liquidity volatility surprise observed in foreign markets (3.5)[22].

In order to estimate GARCH models, it uses maximum likelihood to find the best fit of parameters. As it shows from the preliminary analysis, in most cases, the conditional normality assumption does not hold. Under the non-normality, the usual standard error estimates will be inappropriate; therefore, this study estimates the model with the Quasi-Maximum likelihood method.

The study estimates FTSE100, S&P100, NIKKEI225, Hang Seng, Shen Zhen, and KOSPI100 close-to-close daily liquidity to use with the GARCH-M model. The primary purpose of this initial estimation is to model liquidity volatility and to capture any spillover effect between the UK and East Asian countries and additionally between the UK and the US market.

3.5. EMPIRICAL RESULTS

The main aims of the performed statistical analysis are 1) to model liquidity volatility in the six countries in the sample 2) to ascertain spillover effects of liquidity volatility between international stock markets. It examines how liquidity shocks generated in the UK stock market spill over East Asian countries' stock markets and the other way around. Additionally, this study investigates spillover effects between the UK and the US. The following section presents the results for each of these objectives.

[22] The study estimates equation (3.5) at time t-1 for country A and save residuals denoted by X_{t-1}. Then we add the saved residuals (X_{t-1}) into the variance equation of the equation (3.6) for country B which captures spillover effect from country A to country B.

3.5.1 STOCK MARKET LIQUIDITY VOLATILITY

The study estimates time-varying volatility using the GARCH-M model between 10.04.2006 and 15.03.2010. The reason to choose this period of time is that ask price and bid price for the U.S. are not available before 10.04.2006. Tables 3.5 to 3.9 present the results of absolute liquidity volatility and tables 3.10 to 3.13 present results for proportional liquidity volatility for all six stock exchanges. This initial estimation is for extracting volatility in order to investigate spillover effects.

In the conditional variance equation, the sum of α_1 and β_1 is expected to be less than but close to 1 indicating that the conditional volatility process is persistent and it is weakly stationary. It observes that liquidity volatility is persistent for all six countries. For instance, in the UK / US group (table 3.5), the sum of the two parameters is 0.9478 and 0.9929 respectively. The group of UK and Hong Kong (table 3.6) presents a persistent volatility level. The sum of α_1 and β_1 for UK is 0.9429 and 0.9905 for Hong Kong.

Table 3.5

Volatility of UK and US (ABS)

UK: ARMA(3,6)-GARCH(1,1)-M, US: ARMA(5,7)-GARCH(1,1)-M

(1) $\mathrm{ABSUK}_t = c + \delta_1 \mathrm{ABSUK}_{t-1} + \delta_2 \mathrm{ABSUK}_{t-2} + \delta_3 \mathrm{ABSUK}_{t-3} + \delta_4 \varepsilon_{t-1} + \delta_5 \varepsilon_{t-2} + \delta_6 \varepsilon_{t-3} + \delta_7 \varepsilon_{t-4} + \delta_8 \varepsilon_{t-5} + \delta_9 \varepsilon_{t-6} + \delta_{10} \sigma_t^2 + \delta_{11} D_t + \epsilon_t$

(2) $\mathrm{ABSUS}_t = c + \delta_1 \mathrm{ABSUS}_{t-1} + \delta_2 \mathrm{ABSUS}_{t-2} + \delta_3 \mathrm{ABSUS}_{t-3} + \delta_4 \mathrm{ABSUS}_{t-4} + \delta_5 \mathrm{ABSUS}_{t-5} + \delta_6 \varepsilon_{t-1} + \delta_7 \varepsilon_{t-2} + \delta_8 \varepsilon_{t-3} + \delta_9 \varepsilon_{t-4} + \delta_{10} \varepsilon_{t-5} + \delta_{11} \varepsilon_{t-6} + \delta_{12} \varepsilon_{t-7} + \delta_{13} \sigma_t^2 + \delta_{14} D + \epsilon_t$

(3) $\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$

Where ABSUK stand for Daily Absolute Bid Ask Spread for the US (FTSE100) and ABSUS is Daily Absolute Bid Ask Spread for the US (S&P100). σ_t^2 is conditional variance of ABSUK (1) and ABSUS(2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. P-value is in parentheses.

ABS	Student-t Distribution	
	UK (FTSE100)	US (S&P100)
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	967	964
C	-0.5436 (0.1867)	0.0215 (0.0000)
δ_1	-0.2101 (0.7590)	-0.7866 (0.0000)
δ_2	0.8988 (0.0000)	-0.3955 (0.0000)
δ_3	0.2744 (0.6492)	0.9362 (0.0000)
δ_4	0.4740 (0.4893)	0.6052 (0.0000)
δ_5	-0.6210 (0.0000)	0.4873 (0.0000)
δ_6	-0.1642 (0.7279)	1.0184 (0.0000)
δ_7	-0.0007 (0.9881)	0.7958 (0.0000)
δ_8	-0.0531 (0.0888)	-0.5311 (0.0000)
δ_9	-0.0069 (0.8908)	-0.4206 (0.0000)
δ_{10}	-0.3949 (0.0009)	-0.4956 (0.0000)
δ_{11}	-0.0071 (0.4826)	-0.0746 (0.0544)
δ_{12}		-0.0702 (0.0113)
δ_{13}		2.2820 (0.6551)
δ_{14}		0.0010 (0.0001)
α_1	0.1907 (0.0002)	0.1485 (0.0000)
β_1	0.7571 (0.0000)	0.8434 (0.0000)
Ljung-Box(Q) Test	Q(12) 2.8698 (0.412) Q(22) 9.1415 (0.762) Q(32) 16.041 (0.854)	Q(15) 10.339 (0.016) Q(25) 18.595 (0.136) Q(36) 35.512 (0.061)
Log likelihood	294.6046	3697.65
ARCH LM Test	0.0172 (0.8959)	0.8613 (0.3534)
Skew	9.667590	4.843476
Kurt	154.5644	47.23003
Normality JB	941606.3 (0.0000)	82432.40 (0.0000)
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	967	964

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

Table 3.6
Volatility of UK and H.K. (ABS)

UK: ARMA(6,3)-GARCH(1,1)-M, H.K.: ARMA(7,7)-GARCH(1,1)-M

(1) $\mathrm{ABSUK_t = c + \delta_1 ABSUK_{t-1} + \delta_2 ABSUK_{t-2} + \delta_3 ABSUK_{t-3} + \delta_4 ABSUK_{t-4} + \delta_5 ABSUK_{t-5} + \delta_6 ABSUK_{t-6} + \delta_7 \varepsilon_{t-1} + \delta_8 \varepsilon_{t-2} + \delta_9 \varepsilon_{t-3} + \delta_{10} \sigma_t^2 + \delta_{11} D_t + \epsilon_t}$
(2) $\mathrm{ABSHK_t = c + \delta_1 ABSHK_{t-1} + \delta_2 ABSHK_{t-2} + \delta_3 ABSHK_{t-3} + \delta_4 ABSHK_{t-4} + \delta_5 ABSHK_{t-5} + \delta_6 ABSHK_{t-6} + \delta_7 ABSHK_{t-7} + \delta_8 \varepsilon_{t-1} + \delta_9 \varepsilon_{t-2} + \delta_{10} \varepsilon_{t-3} + \delta_{11} \varepsilon_{t-4} + \delta_{12} \varepsilon_{t-5} + \delta_{13} \varepsilon_{t-6} + \delta_{14} \varepsilon_{t-7} + \delta_{15} \sigma_t^2 + \delta_{16} D_t + \epsilon_t}$
$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$

Where and ABSUK is Daily Absolute Bid Ask Spread for the UK (FTSE100) and ABSHK is Daily Absolute Bid Ask Spread for Hong Kong (Hang Seng). σ_t^2 is conditional variance of ABSUK (1) and ABSHK(2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. P-value is in parentheses.

ABS	Student-t Distribution	
	UK (FTSE100)	Hong Kong (Hang Seng)
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	944	943
C	-0.3791 (0.3467)	0.0055 (0.0000)
δ_1	-0.8579 (0.0000)	1.9937 (0.0000)
δ_2	0.9933 (0.0000)	-3.0696 (0.0000)
δ_3	0.9227 (0.0000)	3.7268 (0.0000)
δ_4	0.0282 (0.6638)	-3.4773 (0.0000)
δ_5	-0.0884 (0.1440)	2.7524 (0.0000)
δ_6	-0.0528 (0.0151)	-1.5656 (0.0000)
δ_7	1.1095 (0.0000)	0.6174 (0.0000)
δ_8	-0.5539 (0.0000)	-1.9225 (0.0000)
δ_9	-0.6697 (0.0000)	3.0489 (0.0000)
δ_{10}	-0.3674 (0.0021)	-3.5993 (0.0000)
δ_{11}	-0.0073 (0.4407)	3.4494 (0.0000)
δ_{12}		-2.6337 (0.0000)
δ_{13}		1.4950 (0.0000)
δ_{14}		-0.5761 (0.0000)
δ_{15}		0.0809 (0.6544)
δ_{16}		-0.0001 (0.1767)
α_1	0.2130 (0.0000)	0.0661 (0.0000)
β_1	0.7319 (0.0000)	0.9244 (0.0000)
Ljung-Box Test	Q(10) 2.7795 (0.095) Q(20) 10.837 (0.457) Q(30) 17.947 (0.652)	Q(15) 4.5569 (0.033) Q(25) 7.9074 (0.722) Q(35) 16.291 (0.753)
Log likelihood	282.0753	5048.637
ARCH LM Test	0.01616 (0.8987)	0.335412 (0.5625)
Skew	9.555322	0.701239
Kurt	152.1022	4.282118
Normality JB	887861.4 (0.0000)	141.7228 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

In table 3.7, UK's $\alpha_1+\beta_1$ is 0.9442 and Japan's $\alpha_1+\beta_1$ is 0.9661. The group of UK and China (table 3.8) shows a similar result, the sum of the $\alpha_1+\beta_1$ for the UK is 0.9586 and 0.9480 for China. In table 3.9, $\alpha_1+\beta_1$ for the UK is 0.9422 and 0.9997 for Korea. Also, the coefficients of α_1 and β_1 in all markets are statistically significant at the 1 % level except α_1 for Japan which is significant at 5% level. The general finding from these parameters is that β_1 in the conditional variance equation is considerably larger than α_1, indicating that shocks to conditional variance takes a long time to die out so the volatility is persistent. The low value of error coefficient α_1 suggests that large market surprises induce relatively small revision in future volatility. The persistence of the conditional variance process, measured by $\alpha_1+\beta_1$, is high and often close to 1 for the countries. This means that the current liquidity level is also relevant in predicting future liquidity volatility at a long horizon.

Table 3.7
Volatility of UK and JAPAN (ABS)

UK: ARMA(5,3)-GARCH(1,1)-M, JAPAN: ARMA(4,3)-GARCH(1,1)-M

(1) $\mathrm{ABSUK_t} = c + \delta_1 \mathrm{ABSUK_{t-1}} + \delta_2 \mathrm{ABSUK_{t-2}} + \delta_3 \mathrm{ABSUK_{t-3}} + \delta_4 \mathrm{ABSUK_{t-4}} + \delta_5 \mathrm{ABSUK_{t-5}} + \delta_6 \varepsilon_{t-1} + \delta_7 \varepsilon_{t-2} + \delta_8 \varepsilon_{t-3} + \delta_9 \sigma_t^2 + \delta_{10} D_t + \epsilon_t$

(2)$\mathrm{ABSJA_t} = c + \delta_1 \mathrm{ABSJA_{t-1}} + \delta_2 \mathrm{ABSJA_{t-2}} + \delta_3 \mathrm{ABSJA_{t-3}} + \delta_4 \mathrm{ABSJA_{t-4}} + \delta_5 \varepsilon_{t-1} + \delta_6 \varepsilon_{t-2} + \delta_7 \varepsilon_{t-3} + \delta_8 \sigma_t^2 + \delta_9 D_t + \epsilon_t$

$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$

Where ABSUK stand for Daily Absolute Bid Ask Spread for the UK (FTSE100) and ABSJA is Daily Absolute Bid Ask Spread for Japan (NIKKEI225). σ_t^2 is conditional variance of ABSUK(1) and ABSJA(2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. P-value is in parentheses.

ABS	Student-t Distribution	Normal Distribution
	UK (FTSE100)	JAPAN (NIKKEI225)
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	927	928
C	-0.5294 (0.2042)	-0.8064 (0.4037)
δ_1	-0.0615 (0.7382)	-0.3036 (0.0000)
δ_2	0.5623 (0.0002)	0.4132 (0.0000)
δ_3	0.5745 (0.0008)	0.9252 (0.0000)
δ_4	-0.0302 (0.4623)	-0.0515 (0.1919)
δ_5	-0.0762 (0.0441)	0.5837 (0.0000)
δ_6	0.3042 (0.1006)	-0.1267 (0.0002)
δ_7	-0.3405 (0.0156)	-0.8035 (0.0000)
δ_8	-0.4336 (0.0022)	-0.0170 (0.0002)
δ_9	-0.4156 (0.0038)	-0.0102 (0.0078)
δ_{10}	-0.0103 (0.2619)	
α_1	0.1555 (0.0003)	0.1403 (0.0189)
β_1	0.7887 (0.0000)	0.8258 (0.0017)
Ljung-Box(Q) Test	Q(09) 3.0269 (0.082) Q(22) 9.2135 (0.817) Q(32) 15.373 (0.909)	Q(08) 3.4179 (0.064) Q(22) 15.615 (0.408) Q(32) 25.118 (0.512)
Log likelihood	300.8837	1183.482
ARCH LM Test	0.027091 (0.8693)	0.0801 (0.7772)
Skew	9.612876	1.097993
Kurt	157.6575	5.649981
Normality JB	938145.8 (0.0000)	457.9970 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

Table 3.8
Volatility of UK and CHINA (ABS)

UK: ARMA(3,4)-GARCH(1,1)-M, CHINA: ARMA(4,6)-GARCH(1,1)-M

(1)$\mathrm{ABSUK_t} = \mathrm{c} + \delta_1 \mathrm{ABSUK_{t-1}} + \delta_2 \mathrm{ABSUK_{t-2}} + \delta_3 \mathrm{ABSUK_{t-3}} + \delta_4 \varepsilon_{t-1} + \delta_5 \varepsilon_{t-2} + \delta_6 \varepsilon_{t-3} + \delta_7 \varepsilon_{t-4} + \delta_8 \sigma_t^2 + \delta_9 \mathrm{D_t} + \epsilon_t$

(2)$\mathrm{ABSCH_t} = \mathrm{c} + \delta_1 \mathrm{ABSCH_{t-1}} + \delta_2 \mathrm{ABSCH_{t-2}} + \delta_3 \mathrm{ABSCH_{t-3}} + \delta_4 \mathrm{ABSCH_{t-4}} + \delta_5 \varepsilon_{t-1} + \delta_6 \varepsilon_{t-2} + \delta_7 \varepsilon_{t-3} + \delta_8 \varepsilon_{t-4} + \delta_9 \varepsilon_{t-5} + \delta_{10} \varepsilon_{t-6} + \delta_{11} \sigma_t^2 + \delta_{12} \mathrm{D_t} + \epsilon_t$
$\sigma_t^2 = \mathrm{c} + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$

Where ABSUK stand for Daily Absolute Bid Ask Spread for the UK (FTSE100) and ABSCH is Daily Absolute Bid Ask Spread for China (Shen Zhen100). σ_t^2 is conditional variance of ABSUK(1) and ABSCH(2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. P-value is in parentheses.

ABS	Student-t Distribution	
	UK (FTSE100)	CHINA (Shen Zhen 100)
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	920	919
c	-0.2247 (0.5359)	-0.0023 (0.0490)
δ_1	0.4281 (0.1067)	1.1009 (0.0000)
δ_2	0.6868 (0.0000)	0.5031 (0.0000)
δ_3	-0.1411 (0.5168)	-1.0766 (0.0000)
δ_4	-0.1737 (0.5148)	0.4505 (0.0000)
δ_5	-0.5564 (0.0000)	-0.8930 (0.0000)
δ_6	0.1705 (0.3127)	-0.5577 (0.0000)
δ_7	-0.0367 (0.2602)	1.0464 (0.0000)
δ_8	-0.3406 (0.0017)	-0.3999 (0.0000)
δ_9	0.0133 (0.1834)	-0.0812 (0.0388)
δ_{10}		0.0555 (0.0391)
δ_{11}		-0.0001 (0.0000)
δ_{12}		3.52E-05 (0.0911)
α_1	0.2421 (0.0002)	0.2554 (0.0037)
β_1	0.7165 (0.0000)	0.6926 (0.0000)
Ljung-Box(Q) Test	Q(10) 4.2899 (0.232) Q(20) 11.829 (0.542) Q(30) 17.239 (0.797)	Q(11) 8.6725 (0.003) Q(20) 13.925 (0.176) Q(30) 23.624 (0.259)
Log likelihood	264.8419	5967.72
ARCH LM Test	0.01811 (0.8929)	0.00505 (0.9433)
Skew	9.630531	2.654180
Kurt	151.4836	19.90515
Normality JB	860304.9 (0.0000)	12009.08 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

Table 3.9
Volatility of UK and KOREA (ABS)

UK: ARMA(5,4)-GARCH(1,1)-M, KOREA: ARMA(6,5)-GARCH(1,1)-M

(1) $ABSUK_t = c + \delta_1 ABSUK_{t-1} + \delta_2 ABSUK_{t-2} + \delta_3 ABSUK_{t-3} + \delta_4 ABSUK_{t-4} + \delta_5 ABSUK_{t-5} + \delta_6 \varepsilon_{t-1} + \delta_7 \varepsilon_{t-2} + \delta_8 \varepsilon_{t-3} + \delta_9 \varepsilon_{t-4} + \delta_{10} \sigma_t^2 + \delta_{11} D_t + \epsilon_t$
(2) $ABSKO_t = c + \delta_1 ABSKO_{t-1} + \delta_2 ABSKO_{t-2} + \delta_3 ABSKO_{t-3} + \delta_4 ABSKO_{t-4} + \delta_5 ABSKO_{t-5} + \delta_6 ABSKO_{t-6} + \delta_7 \varepsilon_{t-1} + \delta_8 \varepsilon_{t-2} + \delta_9 \varepsilon_{t-3} + \delta_{10} \varepsilon_{t-4} + \delta_{11} \varepsilon_{t-5} + \delta_{12} \sigma_t^2 + \delta_{13} D_t + \epsilon_t$

$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$

Where ABSUK stand for Daily Absolute Bid Ask Spread for the UK (FTSE100) and ABSKO is Daily Absolute Bid Ask Spread for Korea (KOSPI100). σ_t^2 is conditional variance of ABSUK(1) and ABSKO(2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. P-value is in parentheses.

ABS	Student-t Distribution	
	UK (FTSE100)	KOREA (KOSPI100)
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	946	946
C	-0.4373 (0.3250)	-0.1834 (0.7192)
δ_1	0.6603 (0.0037)	0.7783 (0.0000)
δ_2	-0.3247 (0.3353)	-0.1167 (0.0014)
δ_3	-0.1074 (0.7496)	-0.0128 (0.0364)
δ_4	0.6991 (0.0022)	0.9934 (0.0000)
δ_5	0.0302 (0.4339)	-0.7116 (0.0000)
δ_6	-0.4161 (0.0661)	0.0635 (0.0550)
δ_7	0.3928 (0.1523)	-0.6616 (0.0000)
δ_8	0.2932 (0.3260)	0.0713 (0.0000)
δ_9	-0.5435 (0.0009)	0.0701 (0.0000)
δ_{10}	-0.3740 (0.0044)	-0.9696 (0.0000)
δ_{11}	-0.0055 (0.5640)	0.6508 (0.0000)
δ_{12}		-0.0098 (0.0087)
δ_{13}		0.0010 (0.7260)
α_1	0.2034 (0.0000)	0.0515 (0.0030)
β_1	0.7388 (0.0000)	0.9482 (0.0000)
Ljung-Box(Q) Test	Q(10) 2.5053 (0.113) Q(20) 7.7541 (0.735) Q(30) 13.25 (0.9000)	Q(12) 6.3787 (0.012) Q(20) 11.751 (0.228) Q(30) 23.472 (0.217)
Log likelihood	293.2608	1521.921
ARCH LM Test	0.01679 (0.8969)	0.74700 (0.3874)
Skew	9.701345	1.172572
Kurt	154.1965	8.100891
Normality JB	913013.8 (0.0000)	1481.715 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

As high volatility indicates high uncertainty, it expects a positive relationship between liquidity volatility and illiquidity levels (bid-ask spread). However, results obtained using ABS are not consistent with the above statement for the UK, Japan, China, and Korea. There is a negative volatility impact on liquidity and the coefficient of σ_t^2 is statistically significant at 1% level for these four countries. On the other hand, the regression result shows a positive coefficient of σ_t^2 for the UK and Hong Kong which implies that an increase in liquidity volatility causes low liquidity level (wide bid-ask spread). However, it is statistically insignificant. Even though it obtains the right sign, it shows that changes in volatility do not have an effect on the level of market liquidity in the UK and Hong Kong. The US, Japan, and China present a significant dummy variable, which means that there is weekend effect for these markets. This means that the bid-ask spread increases on Monday or the day after a holiday for these three markets. Finally, ARCH-LM tests show that the model for the 6 markets above have no further ARCH effects remaining in the model.

For proportional spread (see tables 3.10 to 3.13), NIKKEI 225 is non-stationary. The sum of α_1 and β_1 is 0.9272 for the UK, 0.9501 for the US, 0.9598 for Hong Kong, 0.9458 for Korea and 0.8226 for China. Also these parameters are statistically significant at conventional levels. In terms of the sign for the coefficient of σ_t^2 in the mean equation, it shows a positive relationship between liquidity and liquidity volatility for the UK, the US, Korea and China. This means that an increase in liquidity volatility causes low liquidity level (wide bid-ask spread). Hong Kong, however, shows a negative relationship implying that high liquidity volatility increases liquidity level (narrow bid-ask spread). The coefficient of σ_t^2 is statistically significant at 1% level for the UK, the US, and

China while for Hong Kong and Korea the coefficient of σ_t^2 is statistically insignificant. The U.S. and Hong Kong markets present a significant dummy variable indicating a weekend effect for these markets.

This empirical study observes a mixed result regarding the sign of σ_t^2 in the mean equation. For instance, when it test volatility with absolute bid-ask spread, it observes a negative sign for most markets except the US and Hong Kong. These two markets show a positive sign but the coefficients are statistically insignificant. On the other hand, the study finds an opposite result when it uses proportional bid-ask spread. For example, it shows a positive sign for the UK, the US, Korea and China while Hong Kong shows a negative relationship. The negative relationship obtained in this study can be explained intuitively because there is no study in the literature that can compare to this study directly. For instance, Chordia, Subrahmanyam, and Anshuman (2001) find an unexpected negative relationship between liquidity volatility (use turnover as the liquidity proxy) and stock returns. Pereira and Zhang (2010) support the negative finding of Chordia, Subrahmanyam, and Anshuman (2001). They say that the higher volatility provides more opportunity for investors to time their trade resulted in the negative relationship. Moreover, Keim and Madhavan (1997) emphasize that transaction costs depend on the investment style of traders. For instance, value traders have lower costs than index traders because indexers or technical traders have a strong demand for immediacy while value traders tend to have more patient trading strategies. Value investors adjust their trading to the state of liquidity. Therefore, liquidity volatility presents the dominated investment type during the sample period because liquidity volatility is a consequence of market makers' adjustment based on traders' order submission. This means that the relation between liquidity volatility and market liquidity can be either positive or negative, since bid-ask spread is determined by order inflows made by different types of investors.

Also this study observes a persistent weekend effect for the US, as the coefficient of dummy variable in both absolute and proportional spread is significant. Finally, ARCH-LM tests show that the model for the 5 markets above have no further ARCH effect remaining in the model.

Table 3.10

Volatility of UK and US (PRO)

UK: ARMA(5,7)-GARCH(1,1)-M, US: ARMA(7,7)-GARCH(1,1)-M

(1) $\mathrm{PROUK}_t = c + \delta_1 \mathrm{PROUK}_{t-1} + \delta_2 \mathrm{PROUK}_{t-2} + \delta_3 \mathrm{PROUK}_{t-3} + \delta_4 \mathrm{PROUK}_{t-4} + \delta_5 \mathrm{PROUK}_{t-5} + \delta_6 \varepsilon_{t-1} + \delta_7 \varepsilon_{t-2} + \delta_8 \varepsilon_{t-3} + \delta_9 \varepsilon_{t-4} + \delta_{10} \varepsilon_{t-5} + \delta_{11} \varepsilon_{t-6} + \delta_{12} \varepsilon_{t-7} + \delta_{13} \sigma_t^2 + \delta_{14} D_t + \epsilon_t$

(2) $\mathrm{PROUS}_t = c + \delta_1 \mathrm{PROUS}_{t-1} + \delta_2 \mathrm{PROUS}_{t-2} + \delta_3 \mathrm{PROUS}_{t-3} + \delta_4 \mathrm{PROUS}_{t-4} + \delta_5 \mathrm{PROUS}_{t-5} + \delta_6 \mathrm{PROUS}_{t-6} + \delta_7 \mathrm{PROUS}_{t-7} + \delta_8 \varepsilon_{t-1} + \delta_9 \varepsilon_{t-2} + \delta_{10} \varepsilon_{t-3} + \delta_{11} \varepsilon_{t-4} + \delta_{12} \varepsilon_{t-5} + \delta_{13} \varepsilon_{t-6} + \delta_{14} \varepsilon_{t-7} + \delta_{15} \sigma_t^2 + \delta_{16} D + \epsilon_t$

$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$

Where PROUK stand for Daily Proportional Bid Ask Spread for the UK (FTSE100) and PROUS is Daily Proportional Bid Ask Spread for the US (S&P100). σ_t^2 is conditional variance of PROUK(1) and PROUS(2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. P-value is in parentheses.

PRO	Student-t Distribution	
	UK (FTSE100)	US (S&P100)
Sample period	11/04/2006-15/03/2010	11/04/2006-15/03/2010
Number of Obs.	960	958
c	0.0029 (0.0000)	0.0008 (0.0000)
δ_1	-0.5940 (0.3524)	0.2067 (0.4988)
δ_2	-0.0910 (0.6580)	0.3731 (0.3037)
δ_3	0.3549 (0.0000)	-0.0511 (0.7155)
δ_4	1.0540 (0.0000)	-0.2886 (0.0123)
δ_5	0.2342 (0.7046)	0.1388 (0.3826)
δ_6	0.8399 (0.1882)	0.6941 (0.0000)
δ_7	0.4241 (0.2668)	-0.1768 (0.2466)
δ_8	-4.67E-05 (0.9997)	0.0344 (0.9111)
δ_9	-0.8299 (0.0000)	-0.2556 (0.0405)
δ_{10}	-0.2555 (0.6214)	0.0681 (0.5496)
δ_{11}	-0.0312 (0.5146)	0.3678 (0.0001)
δ_{12}	-0.0366 (0.2325)	-0.0190 (0.9051)
δ_{13}	247.826 (0.0000)	-0.6757 (0.0000)
δ_{14}	-2.0E-05 (0.1255)	0.0868 (0.5612)
δ_{15}		525.254 (0.0011)
δ_{16}		-1.57E-05 (0.0052)
α_1	0.2327 (0.0000)	0.0807 (0.0000)
β_1	0.6945 (0.0000)	0.8701 (0.0000)
Ljung-Box(Q) Test	Q(16) 15.322 (0.004) Q(26) 28.727 (0.011) Q(36) 40.380 (0.019)	Q(12) 16.551 (0.000) Q(22) 24.201 (0.012) Q(32) 30.030 (0.091)
Log likelihood	6705.908	7373.858
ARCH LM Test	0.000148 (0.9903)	0.01494 (0.9027)
Skew	5.596455	5.854292
Kurt	67.02975	63.45699
Normality JB	168651.5 (0.0000)	151191.4 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

Table 3.11
Volatility of UK and H.K. (PRO)

UK: ARMA(2,5)-GARCH(1,1)-M, H.K.: ARMA(5,5)-GARCH(1,1)-M

(1) $\mathrm{PROUK}_t = c + \delta_1 \mathrm{PROUK}_{t-1} + \delta_2 \mathrm{PROUK}_{t-2} + \delta_3 \varepsilon_{t-1} + \delta_4 \varepsilon_{t-2} + \delta_5 \varepsilon_{t-3} + \delta_6 \varepsilon_{t-4} + \delta_7 \varepsilon_{t-5} + \delta_8 \sigma_t^2 + \delta_9 D_t + \epsilon_t$

(2) $\mathrm{PROHK}_t = c + \delta_1 \mathrm{PROHK}_{t-1} + \delta_2 \mathrm{PROHK}_{t-2} + \delta_3 \mathrm{PROHK}_{t-3} + \delta_4 \mathrm{PROHK}_{t-4} + \delta_5 \mathrm{PROHK}_{t-5} + \delta_6 \varepsilon_{t-1} + \delta_7 \varepsilon_{t-2} + \delta_8 \varepsilon_{t-3} + \delta_9 \varepsilon_{t-4} + \delta_{10} \varepsilon_{t-5} + \delta_{11} \sigma_t^2 + \delta_{12} D_t + \epsilon_t$

$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$

Where PROUK stand for Daily Proportional Bid Ask Spread for the UK (FTSE100) and PROHK is Daily Proportional Bid Ask Spread for Hong Kong (Hang Seng). σ_t^2 is conditional variance of PROUK (1) and PROHK (2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. P-value is in parentheses.

PRO	Student-t Distribution	
	UK (FTSE100)	Hong Kong (Hang Seng)
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	944	945
c	0.0028 (0.0001)	9.12E-05 (0.4110)
δ_1	1.8111 (0.0000)	0.8212 (0.6727)
δ_2	-0.8122 (0.0000)	-0.6364 (0.8036)
δ_3	-1.5815 (0.0000)	0.2768 (0.9040)
δ_4	0.5617 (0.0000)	0.3103 (0.8258)
δ_5	0.1347 (0.0317)	0.1977 (0.7254)
δ_6	-0.1674 (0.0056)	-0.6927 (0.7215)
δ_7	0.1275 (0.0260)	0.6879 (0.7665)
δ_8	-0.0490 (0.1039)	-0.1808 (0.9360)
δ_9	249.455 (0.0000)	-0.1758 (0.8877)
δ_{10}	-0.00001 (0.4341)	-0.1323 (0.7406)
δ_{11}		-0.1524 (0.2810)
δ_{12}		-6.08E-06 (0.0197)
α_1	0.0719 (0.0164)	0.1043 (0.0000)
β_1	0.8974 (0.0000)	0.8555 (0.0000)
Ljung-Box(12) Test	Q(10) 4.1613 (0.0413) Q(20) 10.2839 (0.5050)	Q(11) 6.316 (0.012) Q(20) 9.904 (0.449)
Log likelihood	5898.735	8328.961
ARCH LM Test	0.081741 (0.9215)	0.4241 (0.5149)
Skew	1.0430	0.7995
Kurt	3.5326	5.9935
Normality JB	669.69 (0.0000)	453.55 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

Table 3.12
Volatility of UK and KOREA (PRO)

UK: ARMA(6,6)-GARCH(1,1)-M, KOREA: ARMA(3,2)-GARCH(1,1)-M

$$\mathrm{PROUK}_t = c + \delta_1 \mathrm{PROUK}_{t-1} + \delta_2 \mathrm{PROUK}_{t-2} + \delta_3 \mathrm{PROUK}_{t-3} + \delta_4 \mathrm{PROUK}_{t-4} + \delta_5 \mathrm{PROUK}_{t-5} + \delta_6 \mathrm{PROUK}_{t-6} + \delta_7 \varepsilon_{t-1} + \delta_8 \varepsilon_{t-2} + \delta_9 \varepsilon_{t-3} + \delta_{10} \varepsilon_{t-4} + \delta_{11} \varepsilon_{t-5} + \delta_{12} \varepsilon_{t-6} + \delta_{13} \sigma_t^2 + \delta_{14} D_t + \epsilon_t$$

$$\mathrm{PROKO}_t = c + \delta_1 \mathrm{PROKO}_{t-1} + \delta_2 \mathrm{PROKO}_{t-2} + \delta_3 \mathrm{PROKO}_{t-3} + \delta_4 \varepsilon_{t-1} + \delta_5 \varepsilon_{t-2} + \delta_6 \sigma_t^2 + \delta_7 D_t + \epsilon_t$$

$$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$$

Where PROUK stand for Daily Proportional Bid Ask Spread for the UK (FTSE100) and PROKO is Daily Proportional Bid Ask Spread for Korea (KOSPI100). σ_t^2 is conditional variance of PROUK (1) and PROKO (2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. P-value is in parentheses.

PRO	Student-t Distribution	
	UK (FTSE100)	KOREA (KOSPI100)
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	942	945
C	0.0066 (0.0054)	1.55E-06 (0.0000)
δ_1	-1.7446 (0.0000)	0.2191 (0.2072)
δ_2	-0.1087 (0.1040)	0.7983 (0.0000)
δ_3	1.6028 (0.0000)	-0.0543 (0.1656)
δ_4	1.0372 (0.0000)	-0.0352 (0.8380)
δ_5	0.1210 (0.0415)	-0.7531 (0.0000)
δ_6	0.0468 (0.1690)	4.92E-09 (0.2842)
δ_7	1.9569 (0.0000)	-9.7E-09 (0.4361)
δ_8	0.6565 (0.0000)	
δ_9	-1.1013 (0.0000)	
δ_{10}	-0.8853 (0.0000)	
δ_{11}	-0.1288 (0.0026)	
δ_{12}	-0.0394 (0.1910)	
δ_{13}	581.751 (0.0000)	
δ_{14}	-0.00002 (0.0101)	
α_1	0.1251 (0.0000)	0.0406 (0.0184)
β_1	0.7087 (0.0000)	0.9052 (0.0000)
Ljung-Box(Q) Test	Q(13) 8.8614 (0.003) Q(25) 17.668 (0.171) Q(36) 30.338 (0.174)	Q(12) 12.167 (0.095) Q(20) 20.011 (0.172) Q(36) 48.198 (0.025)
Log likelihood	6541.33	13199.18
ARCH LM Test	0.0010 (0.9742)	0.0549 (0.8146)
Skew	5.9780	2.9325
Kurt	66.753	18.8946
Normality JB	16514 (0.0000)	11302 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

Table 3.13

Volatility of UK and CHINA (PRO)

UK: ARMA(8,7)-GARCH(1,1)-M, CHINA: ARMA(6,5)-GARCH(1,1)-M

(1) $PROUK_t = c + \delta_1 PROUK_{t-1} + \delta_2 PROUK_{t-2} + \delta_3 PROUK_{t-3} + \delta_4 PROUK_{t-4} + \delta_5 PROUK_{t-5} + \delta_6 PROUK_{t-6} + \delta_7 PROUK_{t-7} + \delta_8 PROUK_{t-8} + \delta_9 \varepsilon_{t-1} + \delta_{10} \varepsilon_{t-2} + \delta_{11} \varepsilon_{t-3} + \delta_{12} \varepsilon_{t-4} + \delta_{13} \varepsilon_{t-5} + \delta_{14} \varepsilon_{t-6} + \delta_{15} \varepsilon_{t-7} + \delta_{16} \sigma_t^2 + \delta_{17} D_t + \epsilon_t$

(2) $PROCH_t = c + \delta_1 PROCH_{t-1} + \delta_2 PROCH_{t-2} + \delta_3 PROCH_{t-3} + \delta_4 PROCH_{t-4} + \delta_5 PROCH_{t-5} + \delta_6 PROCH_{t-6} + \delta_7 \varepsilon_{t-1} + \delta_8 \varepsilon_{t-2} + \delta_9 \varepsilon_{t-3} + \delta_{10} \varepsilon_{t-4} + \delta_{11} \varepsilon_{t-5} + \delta_{12} \sigma_t^2 + \delta_{13} D + \epsilon_t$

$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$

Where PROUK stand for Daily Proportional Bid Ask Spread for the UK (FTSE100) and PROCH is Daily Proportional Bid Ask Spread for China (Shen Zhen100). σ_t^2 is conditional variance of PROUK (1) and PROCH (2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. P-value is in parentheses.

PRO	Student-t Distribution	
	UK (FTSE100)	CHINA (Shen Zhen 100)
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	919	921
C	0.0002 (0.0000)	0.0002 (0.0732)
δ_1	-0.2582 (0.6634)	0.0689 (0.9570)
δ_2	0.1125 (0.8410)	-0.0792 (0.9260)
δ_3	0.1581 (0.3371)	-0.0134 (0.9860)
δ_4	0.3347 (0.0006)	0.0773 (0.8790)
δ_5	0.7865 (0.0003)	-0.1568 (0.6760)
δ_6	-0.0883 (0.8526)	-0.0143 (0.8390)
δ_7	-0.0806 (0.8526)	-0.0201 (0.9873)
δ_8	-0.0516 (0.2038)	0.0798 (0.9259)
δ_9	0.4901 (0.4078)	0.0279 (0.9715)
δ_{10}	0.1427 (0.8170)	-0.0410 (0.9321)
δ_{11}	0.0971 (0.7793)	0.1724 (0.6557)
δ_{12}	-0.1709 (0.3712)	54.3862 (0.0000)
δ_{13}	-0.7053 (0.0000)	2.27E-05 (0.7238)
δ_{14}	0.0424 (0.9160)	
δ_{15}	0.0481 (0.8952)	
δ_{16}	5363.052 (0.0000)	
δ_{17}	-1.09E-06 (0.3702)	
α_1	0.1210 (0.0000)	0.1297 (0.0000)
β_1	0.7977 (0.0000)	0.6929 (0.0000)
Ljung-Box(12) Test	Q(16) 22.032 (0.000) Q(26) 30.131 (0.002) Q(36) 35.565 (0.024)	Q(12) 1.7620 (0.184) Q(20) 2.1879 (0.988) Q(30) 6.3951 (0.996)
Log likelihood	8675.87	4439.239
ARCH Test	0.0016 (0.9673)	0.0185 (0.8917)
Skew	6.2518	13.2127
Kurt	79.347	213.533
Normality JB	229184 (0.0000)	1727745 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
With Student-t distribution for Shen Zhen, we obtained negative β, thus we decided to use the result with normal distribution.
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

3.5.2 SPILLOVER EFFECT OF STOCK MARKET LIQUIDITY

To capture the volatility spillover effect, the study employs ARMA(p,q)-GARCH(1,1)-M model as it discussed in section 3.4. The parameter X_{t-1} in equation (3.6) can be interpreted as the most recent volatility surprise observed from the foreign market. Even though the finance literature provides ambiguous empirical findings in international stock markets' spillover effect, the study expects X_{t-1} to be statistically significant between UK and other countries due to the enhanced market integration and the increased institutional investment. The primary purpose is to detect spillover effect between international stock markets. More precisely, this study is interested in investigating whether liquidity shocks which occurred in the UK stock market (East Asian markets) spill over to major East Asian stock markets (the UK stock market) such as Japan, Hong Kong, China and Korea. It also adds the US market in order to investigate the potential spillover effect among the biggest two markets (the UK and the US). However, the study does not examine if there are any effects between the US and the East Asian stock markets because this requires a further reduction of the sample size due to non-synchronized trading days. The liquidity spillover estimation for absolute spread and proportional spread is shown in the tables 3.14 to 3.22. Figure 3.3 provides a summary of spillover effects.

3.5.2.1 UK AND US: Table 3.14 (ABS) and Table 3.15 (PRO)

First of all, the absolute spread is interpreted. It shows a statistically significant spillover effect from the UK to the US. The coefficient estimated on the volatility surprise from the UK to the US, γ_2 is statistically significant at the 1% level. There is no significant spillover effect from the US to the UK when ABS is used. When proportional spread is used (PRO), there is a two way relationship between the UK and the US. The coefficients of spillover effects (ν_2) from the US to the UK and from the UK to the US are 9.67E-06 and -2.3E-06 respectively and both if them are statistically significant at 10 % level. The model has been tested for misspecification by ARCH LM test and we find no further ARCH effects in the models. As it is expected that highly integrated markets could have significant spillover effects, there are significant spillover effects between the US and the UK.

Table 3.14
Spillover Estimation between UK and US (ABS)

(1) $ABSUK_t = c + \delta_1 ABSUK_{t-1} + \delta_2 ABSUK_{t-2} + \delta_3 ABSUK_{t-3} + \delta_4 \varepsilon_{t-1} + \delta_5 \varepsilon_{t-2} + \delta_6 \varepsilon_{t-3} + \delta_7 \varepsilon_{t-4} + \delta_8 \varepsilon_{t-5} + \delta_9 \varepsilon_{t-6} + \delta_{10} \sigma_t^2 + \delta_{11} D_t + \epsilon_t$

(2) $ABSUS_t = c + \delta_1 ABSUS_{t-1} + \delta_2 ABSUS_{t-2} + \delta_3 ABSUS_{t-3} + \delta_4 ABSUS_{t-4} + \delta_5 ABSUS_{t-5} + \delta_6 \varepsilon_{t-1} + \delta_7 \varepsilon_{t-2} + \delta_8 \varepsilon_{t-3} + \delta_9 \varepsilon_{t-4} + \delta_{10} \varepsilon_{t-5} + \delta_{11} \varepsilon_{t-6} + \delta_{12} \varepsilon_{t-7} + \delta_{13} \sigma_t^2 + \delta_{14} D + \epsilon_t$

$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma_1 D_t + \gamma_2 X_{t-1}$

Where ABSUK stand for Daily Absolute Bid Ask Spread for the US (FTSE100) and ABSUS is Daily Absolute Bid Ask Spread for the US (S&P100). σ_t^2 is conditional variance of ABSUK (1) and ABSUS(2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. Xt is the residual derived from ARMA(5,7)-GARCH(1,1)-M applied to close to close ABSUS for equation (1) and ARMA(3,6)-GARCH(1,1)-M applied to close to close ABSUK for equation (2). P-value is in parentheses.

ABS	Student-t Distribution	
	From US to UK	From UK to US
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	964	964
c	-0.4378 (0.2505)	0.0264 (0.0000)
δ_1	-0.4314 (0.0000)	0.2106 (0.606)
δ_2	0.4291 (0.0000)	0.1686 (0.6553)
δ_3	0.9490 (0.0000)	0.1442 (0.5675)
δ_4	0.7011 (0.0000)	0.1863 (0.5210)
δ_5	-0.0751 (0.0481)	0.1925 (0.5122)
δ_6	-0.6507 (0.0000)	0.1787 (0.6627)
δ_7	0.0211 (0.5372)	0.1162 (0.7592)
δ_8	-0.0163 (0.6186)	0.0187 (0.9362)
δ_9	-0.0779 (0.0030)	-0.0094 (0.9671)
δ_{10}	-0.3725 (0.0009)	-0.1278 (0.5086)
δ_{11}	-0.0094 (0.3399)	-0.0171 (0.6048)
δ_{12}		0.0711 (0.0527)
δ_{13}		0.00004 (0.784)
δ_{14}		-0.0005 (0.0882)
α_1	0.2153 (0.0003)	0.2697 (0.0000)
β_1	0.7365 (0.0000)	0.6408 (0.0000)
γ_1	0.0020 (0.7957)	-2.0E-07 (0.8959)
γ_2	0.1949 (0.4838)	-1.1E-05 (0.0000)
Ljung-Box(Q) Test	Q(36) 16.862 (0.934)	Q(36) 32.6836 (0.110)
Log likelihood	301.0897	3567.252
ARCH LM Test	0.0170 (0.8961)	0.0039 (0.9498)
Skew	10.03852	10.99099
Kurt	169.2394	201.3276
Normality JB	1126218 (0.0000)	1600977 (0.000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

Table 3.15
Spillover Estimation between UK and US (PRO)

(1) $\mathrm{PROUK_t} = \mathrm{c} + \delta_1\mathrm{PROUK_{t-1}} + \delta_2\mathrm{PROUK_{t-2}} + \delta_3\mathrm{PROUK_{t-3}} + \delta_4\mathrm{PROUK_{t-4}} + \delta_5\mathrm{PROUK_{t-5}} + \delta_6\varepsilon_{t-1} + \delta_7\varepsilon_{t-2} + \delta_8\varepsilon_{t-3} + \delta_9\varepsilon_{t-4} + \delta_{10}\varepsilon_{t-5} + \delta_{11}\varepsilon_{t-6} + \delta_{12}\varepsilon_{t-7} + \delta_{13}\sigma_t^2 + \delta_{14}\mathrm{D_t} + \epsilon_t$

(2) $\mathrm{PROUS_t} = \mathrm{c} + \delta_1\mathrm{PROUS_{t-1}} + \delta_2\mathrm{PROUS_{t-2}} + \delta_3\mathrm{PROUS_{t-3}} + \delta_4\mathrm{PROUS_{t-4}} + \delta_5\mathrm{PROUS_{t-5}} + \delta_6\mathrm{PROUS_{t-6}} + \delta_7\mathrm{PROUS_{t-7}} + \delta_8\varepsilon_{t-1} + \delta_9\varepsilon_{t-2} + \delta_{10}\varepsilon_{t-3} + \delta_{11}\varepsilon_{t-4} + \delta_{12}\varepsilon_{t-5} + \delta_{13}\varepsilon_{t-6} + \delta_{14}\varepsilon_{t-7} + \delta_{15}\sigma_t^2 + \delta_{16}\mathrm{D} + \epsilon_t$

$\sigma_t^2 = \mathrm{c} + \alpha_1\epsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 + \nu_1\mathrm{D_t} + \nu_2\mathrm{X_{t-1}}$

Where PROUK stand for Daily Proportional Bid Ask Spread for the UK (FTSE100) and PROUS is Daily Proportional Bid Ask Spread for the US (S&P100). σ_t^2 is conditional variance of PROUK(1) and PROUS(2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. Xt is the residual derived from ARMA(7,7)-GARCH(1,1)-M applied to close to close PROUS for equation (1) and ARMA(5,7)-GARCH(1,1)-M applied to close to close PROUK for equation (2). P-value is in parentheses.

PRO	Student-t Distribution	
	From US to UK	From UK to US
Sample period	11/04/2006-15/03/2010	11/04/2006-15/03/2010
Number of Obs.	959	957
c	0.0032 (0.0000)	0.0004 (0.0000)
δ_1	0.8963 (0.0000)	0.0179 (0.9827)
δ_2	-0.1270 (0.0000)	0.0170 (0.9848)
δ_3	0.3753 (0.0000)	0.0167 (0.9854)
δ_4	0.6018 (0.0000)	0.0179 (0.9858)
δ_5	-0.7497 (0.0000)	0.0179 (0.9826)
δ_6	-0.6806 (0.0000)	0.0170 (0.9825)
δ_7	0.0851 (0.0000)	0.0170 (0.9757)
δ_8	-0.2866 (0.0000)	0.0169 (0.9837)
δ_9	-0.7041 (0.0000)	0.0160 (0.9855)
δ_{10}	0.6449 (0.0000)	0.0156 (0.9862)
δ_{11}	-0.0062 (0.8614)	0.0167 (0.9863)
δ_{12}	0.0021 (0.9414)	0.0168 (0.9834)
δ_{13}	443.0419 (0.0000)	0.0158 (0.9834)
δ_{14}	8.25E-08 (0.9952)	0.0159 (0.9764)
δ_{15}		966.99 (0.0000)
δ_{16}		0.00002 (0.0181)
α_1	0.1863 (0.0000)	0.1823 (0.0000)
β_1	0.7081 (0.0000)	0.6165 (0.0000)
ν_1	-1.5E-09 (0.8244)	-5.6E-09 (0.0000)
ν_2	9.67E-06 (0.0867)	-2.3E-06 (0.0677)
Ljung-Box(Q) Test	Q(35) 42.643 (0.007)	Q(35) 0.0022 (0.000)
Log likelihood	6665.153	6936.54
ARCH LM Test	0.000014 (0.9969)	0.0729 (0.7871))
Skew	5.587884	6.989701
Kurt	70.86238	97.18355
Normality JB	188616.7 (0.0000)	361505.4 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

3.5.2.2. UK AND HONG KONG: Table 3.16 (ABS) and Table 3.17 (PRO)

A spillover effect is detected from the UK to Hong Kong. The coefficient γ_2 for ABS is 0.00013 (p-value of 0.0612). The study does not find a spillover effect from Hong Kong to the UK. When it tests for a spillover effect with PRO, it obtains an opposite result to the result of ABS. It shows a statistically significant (at 10%) spillover effect from Hong Kong to the UK. The coefficient ν_2 is 0.000017 (p-value of 0.0783). This study does not find a spillover effect from the UK to Hong Kong. The ARCH-LM tests show that there is no ARCH effect remaining. Generally speaking the results obtained do not help establish a clear relation between Hong Kong and the UK.

3.5.2.3 UK AND JAPAN: Table 3.18 (ABS)

In this empirical test, only absolute spread is examined since NIKKEI225 PRO is non-stationary. The coefficient of spillover effect generated from UK to Japan is statistically insignificant indicating that liquidity shocks in the UK do not spill over to the Japanese stock market. However, it finds evidence of spillover effects from Japan to the UK. The coefficient of spillover is 0.043 (p-value: 0.0932). The ARCH-LM test shows that there is no further ARCH effect in the model.

Table 3.16
Spillover Estimation between UK and H.K. (ABS)

(1) $ABSUK_t = c + \delta_1 ABSUK_{t-1} + \delta_2 ABSUK_{t-2} + \delta_3 ABSUK_{t-3} + \delta_4 ABSUK_{t-4} + \delta_5 ABSUK_{t-5} + \delta_6 ABSUK_{t-6} + \delta_7 \varepsilon_{t-1} + \delta_8 \varepsilon_{t-2} + \delta_9 \varepsilon_{t-3} + \delta_{10} \sigma_t^2 + \delta_{11} D_t + \epsilon_t$

(2) $ABSHK_t = c + \delta_1 ABSHK_{t-1} + \delta_2 ABSHK_{t-2} + \delta_3 ABSHK_{t-3} + \delta_4 ABSHK_{t-4} + \delta_5 ABSHK_{t-5} + \delta_6 ABSHK_{t-6} + \delta_7 ABSHK_{t-7} + \delta_8 \varepsilon_{t-1} + \delta_9 \varepsilon_{t-2} + \delta_{10} \varepsilon_{t-3} + \delta_{11} \varepsilon_{t-4} + \delta_{12} \varepsilon_{t-5} + \delta_{13} \varepsilon_{t-6} + \delta_{14} \varepsilon_{t-7} + \delta_{15} \sigma_t^2 + \delta_{16} D_t + \epsilon_t$

$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma_1 D_t + \gamma_2 X_{t-1}$

Where and ABSUK is Daily Absolute Bid Ask Spread for the UK (FTSE100) and ABSHK is Daily Absolute Bid Ask Spread for Hong Kong (Hang Seng). σ_t^2 is conditional variance of ABSUK (1) and ABSHK(2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. Xt is the residual derived from ARMA(7,7)-GARCH(1,1)-M applied to close to close ABSHK for equation(1) and ARMA(6,3)-GARCH(1,1)-M applied to close to close ABSUK for equation (2). P-value is in parentheses.

ABS	Student-t Distribution	
	From H.K to UK	From UK to H.K.
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	943	941
c	-0.5027 (0.2529)	0.0058 (0.0000)
δ_1	0.5669 (0.0000)	0.8436 (0.0028)
δ_2	-0.4516 (0.0000)	-0.6577 (0.0050)
δ_3	0.9890 (0.0000)	0.7799 (0.0000)
δ_4	-0.0869 (0.0745)	-0.4257 (0.0569)
δ_5	0.0256 (0.4932)	0.7139 (0.0000)
δ_6	-0.0732 (0.0422)	-0.4576 (0.0260)
δ_7	-0.3168 (0.0000)	0.1788 (0.2440)
δ_8	0.5480 (0.0000)	-0.0127 (0.8420)
δ_9	-0.7122 (0.0000)	-0.7659 (0.0065)
δ_{10}	-0.3733 (0.0021)	0.7105 (0.0012)
δ_{11}	-0.0069 (0.4630)	-0.6966 (0.0000)
δ_{12}		0.5013 (0.0132)
δ_{13}		-0.2838 (0.0337)
δ_{14}		0.2370 (0.1600)
δ_{15}		0.0001 (0.0222)
α_1	0.2094 (0.0002)	0.0544 (0.0001)
β_1	0.7316 (0.0000)	0.9365 (0.0000)
γ_1	-0.0021 (0.7907)	-1.2E-07 (0.309)
γ_2	13.6107 (0.7261)	0.00013 (0.0612)
Ljung-Box Test	Q(35) 18.836 (0.875)	Q(35) 26.8939 (0.138)
Log likelihood	283.1385	5038.172
ARCH LM Test	0.0163 (0.8984)	0.7705 (0.3800)
Skew	3.584315	0.727064
Kurt	65.81283	4.389183
Normality JB	156709.5 (0.0000)	158.5711 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
For the UK to Hong Kong, We obtained result from normal distribution because student-t distribution failed to improve likelihood.
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

Table 3.17
Spillover Estimation between UK and H.K. (PRO)

(1) $PROUK_t = c + \delta_1 PROUK_{t-1} + \delta_2 PROUK_{t-2} + \delta_3 \varepsilon_{t-1} + \delta_4 \varepsilon_{t-2} + \delta_5 \varepsilon_{t-3} + \delta_6 \varepsilon_{t-4} + \delta_7 \varepsilon_{t-5} + \delta_8 \sigma_t^2 + \delta_9 D_t + \epsilon_t$

(2) $PROHK_t = c + \delta_1 PROHK_{t-1} + \delta_2 PROHK_{t-2} + \delta_3 PROHK_{t-3} + \delta_4 PROHK_{t-4} + \delta_5 PROHK_{t-5} + \delta_6 \varepsilon_{t-1} + \delta_7 \varepsilon_{t-2} + \delta_8 \varepsilon_{t-3} + \delta_9 \varepsilon_{t-4} + \delta_{10} \varepsilon_{t-5} + \delta_{11} \sigma_t^2 + \delta_{12} D_t + \epsilon_t$

$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \nu_1 D_t + \nu_2 X_{t-1}$

Where PROUK stand for Daily Proportional Bid Ask Spread for the UK (FTSE100) and PROHK is Daily Proportional Bid Ask Spread for Hong Kong (Hang Seng). σ_t^2 is conditional variance of PROUK (1) and PROHK (2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. Xt is the residual derived from ARMA(5,5)-GARCH(1,1)-M applied to close to close PROHK for equation (1) and ARMA(2,5)-GARCH(1,1)-M applied to close to close PROUK for equation (2). P-value is in parentheses.

PRO	Student-t Distribution	
	From H.K. to UK	From UK to H.K.
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	944	944
c	0.5538 (0.0000)	5.64E-06 (0.9667)
δ_1	-0.1203 (0.0000)	2.2506 (0.0000)
δ_2	-0.1036 (0.0000)	-3.2368 (0.0000)
δ_3	0.4122 (0.0000)	3.0946 (0.0000)
δ_4	0.2539 (0.0000)	-1.8351 (0.0000)
δ_5	0.1246 (0.0000)	0.7120 (0.0000)
δ_6	-0.0178 (0.3671)	-2.1021 (0.0000)
δ_7	-0.2550 (0.0000)	3.0634 (0.0000)
δ_8	0.0395 (0.0000)	-2.8133 (0.0000)
δ_9	0.00007 (0.5858)	1.7216 (0.0000)
δ_{10}		-0.6263 (0.0000)
δ_{11}		-0.2930 (0.0254)
δ_{12}		-6.57E-06 (0.0066)
α_1	0.00003 (0.5361)	0.0828 (0.0001)
β_1	0.2451 (0.0000)	0.8895 (0.0000)
ν_1	-3.23E-09 (0.4304)	-1.1E-10 (0.4958)
ν_2	1.72E-05 (0.0783)	1.23E-07 (0.2511)
Ljung-Box(12) Test	Q(35) 119.51 (0.000)	Q(35) 11.4393 (0.9904)
Log likelihood	5191.94	8334.581
ARCH LM Test	1.1739 (0.2785)	0.5846 (0.4445)
Skew	6.089249	1.0118
Kurt	81.06673	3.5145
Normality JB	248408.6 (0.0000)	654.44 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)]. The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)]. For the spillover test, FTSE100 runs with ARMA(2,5) because estimated AR process is non-stationary based on inverted AR Roots test therefore we replaced by ARMA(2,5) instead of ARMA(2,6). From UK to H.K. spillover effect, adding dummy variable in the variance equation causes no convergence. Thus we did not add dummy variable in variance equation.. *,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

Table 3.18
Spillover Estimation between UK and JAPAN (ABS)

(1) $\mathrm{ABSUK}_t = c + \delta_1 \mathrm{ABSUK}_{t-1} + \delta_2 \mathrm{ABSUK}_{t-2} + \delta_3 \mathrm{ABSUK}_{t-3} + \delta_4 \mathrm{ABSUK}_{t-4} + \delta_5 \mathrm{ABSUK}_{t-5} + \delta_6 \varepsilon_{t-1} + \delta_7 \varepsilon_{t-2} + \delta_8 \varepsilon_{t-3} + \delta_9 \sigma_t^2 + \delta_{10} D_t + \epsilon_t$
(2) $\mathrm{ABSJA}_t = c + \delta_1 \mathrm{ABSJA}_{t-1} + \delta_2 \mathrm{ABSJA}_{t-2} + \delta_3 \mathrm{ABSJA}_{t-3} + \delta_4 \mathrm{ABSJA}_{t-4} + \delta_5 \varepsilon_{t-1} + \delta_6 \varepsilon_{t-2} + \delta_7 \varepsilon_{t-3} + \delta_8 \sigma_t^2 + \delta_9 D_t + \epsilon_t$

$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma_1 D_t + \gamma_2 X_{t-1}$

Where ABSUK stand for Daily Absolute Bid Ask Spread for the UK (FTSE100) and ABSJA is Daily Absolute Bid Ask Spread for Japan (NIKKEI225). σ_t^2 is conditional variance of ABSUK(1) and ABSJA(2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. Xt is the residual derived from ARMA(4,3)-GARCH(1,1)-M applied to close to close ABSJA for equation(1) and ARMA(5,3)-GARCH(1,1)-M applied to close to close ABSUK for equation (2). P-value is in parentheses.

ABS	Student-t Distribution	
	From JAPAN to UK	From UK to JAPAN
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	926	926
C	-0.5286 (0.2445)	-0.7941 (0.3072)
δ_1	-0.8545 (0.0000)	-0.3019 (0.0000)
δ_2	0.0386 (0.4352)	0.4050 (0.0000)
δ_3	1.0450 (0.0000)	0.9127 (0.0000)
δ_4	0.7183 (0.0005)	-0.0366 (0.3600)
δ_5	-0.0152 (0.6903)	0.5769 (0.0000)
δ_6	1.1096 (0.0000)	-0.1234 (0.0004)
δ_7	0.3962 (0.0000)	-0.7812 (0.0000)
δ_8	-0.6309 (0.0000)	-0.0216 (0.0000)
δ_9	-0.5604 (0.0003)	-0.0102 (0.0078)
δ_{10}	-0.3493 (0.0056)	
δ_{11}	-0.0103 (0.2619)	
α_1	0.1819 (0.0008)	0.1403 (0.0021)
β_1	0.7718 (0.0000)	0.8105 (0.0000)
γ_1	0.0046 (0.5298)	0.0008 (0.2336)
γ_2	0.0430 (0.0932)	-0.00004 (0.9487)
Ljung-Box(Q) Test	Q(35) 20.8930 (0.747)	Q(35) 30.187 (0.354)
Log likelihood	306.8941	1177.26
ARCH LM Test	0.02678 (0.8699)	1.3223 (0.2501)
Skew	9.824110	1.061457
Kurt	165.0486	5.366450
Normality JB	1028084.0 (0.0000)	389.9558 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
For the JAPAN, we have no convergence with student-t distribution.
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

3.5.2.4 UK AND CHINA: Table 3.19 (ABS) and Table 3.20 (PRO)

When the study uses daily absolute spread (table 3.19), it confirms a spillover effect from the UK to China. The coefficient of spillover effect (γ_2) for the Chinese market is 2.3E-07 and it is statistically significant at 1% while there is no spillover effect from China to the UK. The coefficient is insignificant (2.5249 and p-value of 0.6509). However, based on proportional spread (table 3.20), it finds a strong spillover effect between the UK and China. X_{t-1} in the conditional variance equation is statistically significant at the 1% level in both directions. Thus, liquidity shocks from these two markets are transmitting to each other. ARCH LM test does not reject the null hypothesis of no further ARCH effect in the model for all tests.

3.5.2.5 UK and KOREA: Table 3.21 (ABS) and Table 3.22 (PRO)

In table 3.21, it shows no spillover effect from Korea to the UK for ABS. The coefficient of spillover effect is -0.0001 (p-value of 0.7406). From the UK to Korea, the coefficient of X_{t-1} for absolute spread is -0.5954 and the p-value is 0.0183 indicating a statistically significant spillover effect. Proportional spread (table 3.22) shows a significant spillover between the UK and Korea. The coefficient of spillover parameter (ν_2) on the UK market is 0.0233 and its p-value is 0.0009. The coefficient of X_{t-1} for Korea is 1.72E-11 and p-value is 0.0242. Thus, liquidity shocks from these two markets are transmitting to each other. The ARCH-LM tests show that there is no ARCH effect in the model.

Table 3.19
Spillover Estimation between UK and CHINA (ABS)

$(1) \mathrm{ABSUK}_t = c + \delta_1 \mathrm{ABSUK}_{t-1} + \delta_2 \mathrm{ABSUK}_{t-2} + \delta_3 \mathrm{ABSUK}_{t-3} + \delta_4 \varepsilon_{t-1} + \delta_5 \varepsilon_{t-2} + \delta_6 \varepsilon_{t-3} + \delta_7 \varepsilon_{t-4} + \delta_8 \sigma_t^2 + \delta_9 D_t + \epsilon_t$

$(2) \mathrm{ABSCH}_t = c + \delta_1 \mathrm{ABSCH}_{t-1} + \delta_2 \mathrm{ABSCH}_{t-2} + \delta_3 \mathrm{ABSCH}_{t-3} + \delta_4 \mathrm{ABSCH}_{t-4} + \delta_5 \varepsilon_{t-1} + \delta_6 \varepsilon_{t-2} + \delta_7 \varepsilon_{t-3} + \delta_8 \varepsilon_{t-4} + \delta_9 \varepsilon_{t-5} + \delta_{10} \varepsilon_{t-6} + \delta_{11} \sigma_t^2 + \delta_{12} D_t + \epsilon_t$

$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma_1 D_t + \gamma_2 X_{t-1}$

Where ABSUK stand for Daily Absolute Bid Ask Spread for the UK (FTSE100) and ABSCH is Daily Absolute Bid Ask Spread for China (Shen Zhen100). σ_t^2 is conditional variance of ABSUK(1) and ABSCH(2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. Xt is the residual derived from ARMA(4,6)-GARCH(1,1)-M applied to close to close ABSCH for equation(1) and ARMA(3,4)-GARCH(1,1)-M applied to close to close ABSUK for equation (2). P-value is in parentheses.

ABS	Student-t Distribution	
	From CHINA to UK	From UK to CHINA
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	919	919
c	-0.2668 (0.4791)	0.0118 (0.0000)
δ_1	-0.1858 (0.7026)	0.0076 (0.7747)
δ_2	0.7470 (0.0000)	0.0061 (0.9524)
δ_3	0.3907 (0.3041)	0.0172 (0.8645)
δ_4	0.4478 (0.3597)	0.0124 (0.6760)
δ_5	-0.4673 (0.0000)	0.0062 (0.8803)
δ_6	-0.2397 (0.4149)	0.0039 (0.9701)
δ_7	0.0122 (0.7537)	0.0110 (0.9124)
δ_8	-0.3515 (0.0016)	0.0041 (0.9067)
δ_9	0.0041 (0.6982)	0.0035 (0.8475)
δ_{10}		0.0054 (0.7703)
δ_{11}		0.0006 (0.0000)
δ_{12}		-0.0004 (0.0000)
α_1	0.2380 (0.0004)	0.1572 (0.0000)
β_1	0.7161 (0.0000)	0.6099 (0.0000)
γ_1	0.0014 (0.8668)	7.04E-08 (0.0000)
γ_2	2.5249 (0.6509)	2.3E-07 (0.0000)
Ljung-Box(Q) Test	Q(35) 19.927 (0.887)	Q(35) 37.492 (0.051)
Log likelihood	262.326	5536.236
ARCH LM Test	0.0186 (0.8914)	0.6745 (0.4115)
Skew	9.618052	2.879787
Kurt	150.9955	23.49687
Normality JB	851002.6 (0.0000)	17319.63 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

Table 3.20
Spillover Estimation between UK and CHINA (PRO)

(1) $\mathrm{PROUK_t = c + \delta_1 PROUK_{t-1} + \delta_2 PROUK_{t-2} + \delta_3 PROUK_{t-3} + \delta_4 PROUK_{t-4} + \delta_5 PROUK_{t-5} + \delta_6 PROUK_{t-6} + \delta_7 PROUK_{t-7} + \delta_8 PROUK_{t-8} + \delta_9 \varepsilon_{t-1} + \delta_{10} \varepsilon_{t-2} + \delta_{11} \varepsilon_{t-3} + \delta_{12} \varepsilon_{t-4} + \delta_{13} \varepsilon_{t-5} + \delta_{14} \varepsilon_{t-6} + \delta_{15} \varepsilon_{t-7} + \delta_{16} \sigma_t^2 + \delta_{17} D_t + \epsilon_t}$

(2) $\mathrm{PROCH_t = c + \delta_1 PROCH_{t-1} + \delta_2 PROCH_{t-2} + \delta_3 PROCH_{t-3} + \delta_4 PROCH_{t-4} + \delta_5 PROCH_{t-5} + \delta_6 PROCH_{t-6} + \delta_7 \varepsilon_{t-1} + \delta_8 \varepsilon_{t-2} + \delta_9 \varepsilon_{t-3} + \delta_{10} \varepsilon_{t-4} + \delta_{11} \varepsilon_{t-5} + \delta_{12} \sigma_t^2 + \delta_{13} D + \epsilon_t}$

$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \nu_1 D_t + \nu_2 X_{t-1}$

Where PROUK stand for Daily Proportional Bid Ask Spread for the UK (FTSE100) and PROCH is Daily Proportional Bid Ask Spread for China (Shen Zhen100). σ_t^2 is conditional variance of PROUK (1) and PROCH (2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. Xt is the residual derived from ARMA(6,5)-GARCH(1,1)-M applied to close to close PROCH for equation (1) and ARMA(8,7)-GARCH(1,1)-M applied to close to close PROUK for equation (2). P-value is in parentheses.

PRO	Student-t Distribution	
	From CHINA to UK	From UK to CHINA
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	918	918
c	0.0003 (0.0000)	0.00027 (0.1878)
δ_1	-0.1844 (0.6673)	0.0161 (0.9946)
δ_2	-0.0511 (0.8861)	0.0005 (0.9992)
δ_3	0.2982 (0.4523)	0.0059 (0.9936)
δ_4	0.7840 (0.0000)	0.0242 (0.9674)
δ_5	0.0854 (0.8208)	0.0145 (0.9707)
δ_6	0.0920 (0.7692)	-0.0149 (0.8741)
δ_7	-0.1021 (0.7405)	0.0167 (0.9944)
δ_8	0.0245 (0.5958)	0.0006 (0.9991)
δ_9	0.4205 (0.3267)	0.0052 (0.9943)
δ_{10}	0.2992 (0.4206)	0.0224 (0.9684)
δ_{11}	0.0056 (0.9895)	0.0145 (0.9714)
δ_{12}	-0.6140 (0.0000)	53.1681 (0.0000)
δ_{13}	-0.0941 (0.7660)	-4.5E-05 (0.8277)
δ_{14}	-0.1004 (0.6807)	
δ_{15}	0.0770 (0.7691)	
δ_{16}	5368.086 (0.0000)	
δ_{17}	-6.8E-07 (0.5211)	
α_1	0.1521 (0.0000)	0.1556 (0.0000)
β_1	0.7403 (0.0000)	0.5499 (0.0000)
ν_1	-5.8E-11 (0.0062)	-2.5E-07 (0.1465)
ν_2	6.4E-09 (0.0005)	0.0201 (0.0000)
Ljung-Box(12) Test	Q(35) 31.073 (0.072)	Q(35) 21.174 (0.628)
Log likelihood	8661.888	4218.063
ARCH Test	0.0021 (0.9634)	0.0399 (0.8416)
Skew	5.945527	7.605106
Kurt	70.72175	71.03153
Normality JB	180832.0 (0.0000)	185881.2 (0.000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

Table 3.21
Spillover Estimation between UK and KOREA (ABS)

(1) $\mathrm{ABSUK_t = c + \delta_1 ABSUK_{t-1} + \delta_2 ABSUK_{t-2} + \delta_3 ABSUK_{t-3} + \delta_4 ABSUK_{t-4} + \delta_5 ABSUK_{t-5} + \delta_6 \varepsilon_{t-1} + \delta_7 \varepsilon_{t-2} + \delta_8 \varepsilon_{t-3} + \delta_9 \varepsilon_{t-4} + \delta_{10} \sigma_t^2 + \delta_{11} D_t + \epsilon_t}$

(2) $\mathrm{ABSKO_t = c + \delta_1 ABSKO_{t-1} + \delta_2 ABSKO_{t-2} + \delta_3 ABSKO_{t-3} + \delta_4 ABSKO_{t-4} + \delta_5 ABSKO_{t-5} + \delta_6 ABSKO_{t-6} + \delta_7 \varepsilon_{t-1} + \delta_8 \varepsilon_{t-2} + \delta_9 \varepsilon_{t-3} + \delta_{10} \varepsilon_{t-4} + \delta_{11} \varepsilon_{t-5} + \delta_{12} \sigma_t^2 + \delta_{13} D_t + \epsilon_t}$

$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma_1 D_t + \gamma_2 X_{t-1}$

Where ABSUK stand for Daily Absolute Bid Ask Spread for the UK (FTSE100) and ABSKO is Daily Absolute Bid Ask Spread for Korea (KOSPI100). σ_t^2 is conditional variance of ABSUK(1) and ABSKO(2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. Xt is the residual derived from ARMA(6,5)-GARCH(1,1)-M applied to close to close ABSKO for equation(1) and ARMA(5,4)-GARCH(1,1)-M applied to close to close ABSUK for equation (2). P-value is in parentheses.

ABS	Student-t Distribution	
	From KOREA to UK	From UK to KOREA
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	945	946
c	0.4334 (0.2354)	-0.0255 (0.8981)
δ_1	0.1261 (0.1894)	1.5131 (0.0000)
δ_2	0.1674 (0.0714)	-1.3747 (0.0000)
δ_3	0.1821 (0.0279)	1.3270 (0.0000)
δ_4	0.1673 (0.0435)	-0.3250 (0.0000)
δ_5	0.2607 (0.0000)	-0.1431 (0.0000)
δ_6	0.1629 (0.0891)	-0.0021 (0.6540)
δ_7	0.0928 (0.2926)	-1.3959 (0.0000)
δ_8	0.0653 (0.3659)	1.2349 (0.0000)
δ_9	0.0281 (0.6529)	-1.1400 (0.0000)
δ_{10}	0.3122 (0.0108)	0.1903 (0.0000)
δ_{11}	-0.0333 (0.0048)	0.2018 (0.0000)
δ_{12}		-0.0076 (0.0529)
δ_{13}		-0.0061 (0.0459)
α_1	0.1370 (0.0172)	0.0534 (0.0094)
β_1	0.5112 (0.0000)	0.9462 (0.0000)
γ_1	-0.2028 (0.0109)	-0.00003 (0.9329)
γ_2	-0.5954 (0.0183)	0.0001 (0.7406)
Ljung-Box(Q) Test	Q(35) 33.6618 (0.143)	Q(35) 25.4411 (0.415)
Log likelihood	157.3875	1519.465
ARCH LM Test	0.2306 (0.6311)	1.3588 (0.2437)
Skew	9.773560	1.708661
Kurt	157.9396	8.245545
Normality JB	956227.1 (0.0000)	1536.725 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

Table 3.22
Spillover Estimation between UK and KOREA (PRO)

$$\mathrm{PROUK}_t = c + \delta_1 \mathrm{PROUK}_{t-1} + \delta_2 \mathrm{PROUK}_{t-2} + \delta_3 \mathrm{PROUK}_{t-3} + \delta_4 \mathrm{PROUK}_{t-4} + \delta_5 \mathrm{PROUK}_{t-5} + \delta_6 \mathrm{PROUK}_{t-6} + \delta_7 \varepsilon_{t-1} + \delta_8 \varepsilon_{t-2} + \delta_9 \varepsilon_{t-3} + \delta_{10} \varepsilon_{t-4} + \delta_{11} \varepsilon_{t-5} + \delta_{12} \varepsilon_{t-6} + \delta_{13} \sigma_t^2 + \delta_{14} D_t + \epsilon_t$$

$$\mathrm{PROKO}_t = c + \delta_1 \mathrm{PROKO}_{t-1} + \delta_2 \mathrm{PROKO}_{t-2} + \delta_3 \mathrm{PROKO}_{t-3} + \delta_4 \varepsilon_{t-1} + \delta_5 \varepsilon_{t-2} + \delta_6 \sigma_t^2 + \delta_7 D_t + \epsilon_t$$

$$\sigma_t^2 = c + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \nu_1 D_t + \nu_2 X_{t-1}$$

Where PROUK stand for Daily Proportional Bid Ask Spread for the UK (FTSE100) and PROKO is Daily Proportional Bid Ask Spread for Korea (KOSPI100). σ_t^2 is conditional variance of PROUK (1) and PROKO (2), and the D is the weekend dummy variable that equals 1 on a day following a weekend or holiday or 0 otherwise. Xt is the residual derived from ARMA(3,2)-GARCH(1,1)-M applied to close to close PROKO for equation (1) and ARMA(6,6)-GARCH(1,1)-M applied to close to close PROUK for equation (2). P-value is in parentheses.

PRO	Student-t Distribution	
	From KOREA to UK	From UK to KOREA
Sample period	10/04/2006 – 15/03/2010	10/04/2006 – 15/03/2010
Number of Obs.	941	941
C	0.0065 (0.0057)	0.000001 (0.0000)
δ_1	-1.0567 (0.0000)	0.0791 (0.0096)
δ_2	0.1256 (0.0079)	0.9654 (0.0000)
δ_3	0.7742 (0.0000)	-0.0840 (0.0030)
δ_4	1.2238 (0.0000)	0.1061 (0.0000)
δ_5	0.2688 (0.0000)	-0.8821 (0.0000)
δ_6	-0.3670 (0.0000)	5.86E-09 (0.1040)
δ_7	1.2696 (0.0000)	-7.7E-09 (0.4994)
δ_8	0.2919 (0.0000)	
δ_9	-0.4084 (0.0000)	
δ_{10}	-1.0582 (0.0000)	
δ_{11}	-0.3552 (0.0000)	
δ_{12}	0.2774 (0.0000)	
δ_{13}	577.44 (0.0000)	
δ_{14}	-1.9E-005 (0.1391)	
α_1	0.1151 (0.0000)	0.0525 (0.0269)
β_1	0.6819 (0.0000)	0.8848 (0.0000)
ν_1	3.3E-09 (0.6704)	-2.12E-14 (0.0019)
ν_2	0.0233 (0.0009)	1.72E-11 (0.0242)
Ljung-Box(Q) Test	Q(35) 30.8049 (0.127)	Q(35) 47.776 (0.028)
Log likelihood	6549.362	13151.47
ARCH LM Test	0.0070 (9329)	0.2726 (0.6015)
Skew	1.644321	2.6141
Kurt	11.67825	16.0271
Normality JB	3376.904 (0.0000)	7725.601 (0.0000)

Ljung-Box test decision rule: H_0: No serial correlation →Do not reject H_0 when p-value is high [Q<Chisq(lag)].
The ARCH-LM test decision rule: H_0: there is no ARCH up to order q in the residual → Do not reject when p-value is high [Q<Chisq(lag)].
*,**,*** indicate statistically significant at 1%, 5%, and 10% respectively

From the summary table of spillover effects (figure 3.3), it can say that shocks of liquidity volatility in the UK are transmitted (using either ABS or PRO) to all countries except Japan. In the case of Japan, the stock market of Japan could be more robust against exogenous risks compared with other Asian markets in relationship with the UK market. The existence of spillover effect from Japan to the UK could be the overnight effect that contains early information generated by the US market (please see the end of section 3.3.1).

Figure 3.3: The Summary of Spillover Effect

UK & US	ABS		PRO	
	To UK	*To US*	*To UK*	*To US*
From UK		→		→
From US	×		×	
UK & HK	ABS		PRO	
	To UK	*To H.K*	*To UK*	*To H.K.*
From UK		→		×
From H.K.	×		→	
UK & JAPAN	ABS		PRO	
	To UK	*To Japan*		
From UK		×		
From Japan	→			
UK & CHINA	ABS		PRO	
	To UK	*To China*	*To UK*	*To China*
From UK		→		→
From China	×		→	
UK & KOREA	ABS		PRO	
	To UK	*To Korea*	*To UK*	*To Korea*
From UK		×		→
From Korea	→		→	

Where ABS stand for daily average absolute bid ask spread. Daily average proportional bid ask spread denoted as PRO.
→ indicates spillover effect exists and × shows no spillover effect.

3.6. ROBUSTNESS

This section addresses some remaining concerns about the results obtained. In order to perform robustness tests. The Granger Causality test is fulfilled for all countries in the sample, using the same variables namely ABS and PRO.

The idea of Granger-causality is that a variable X Granger-causes variable Y if variable Y can be better predicted using the histories of both X and Y than it can be predicted using the history of Y alone. If, in a regression of Y_t on lagged values of Y_t and X_t, the coefficients of the X_t values are zero then the series X_t fails to Granger –cause Y_t. So consider the following regression model

$$Y_t = \sum_{j=1}^{m} \alpha_j Y_{t-1} + \sum_{i=1}^{n} \beta_i X_{t-1} + \varepsilon_t \tag{3.7}$$

Where ε_t is the random error term, α_j is the coefficient on the lagged Y values, and β_i is the coefficient on the lagged X values. If β_i is zero (for i =1,2,…,n) then X fails to Granger-cause Y. In this case, variable Y_t is liquidity (ABS and PRO) and X_{t-1} is saved residuals from equation 3.2 for the selected countries. The number of lags to be included is chosen using the Akaike information Criterion.

Table 3.23 presents the results of tests. Between the UK and US, it obtains a positive two way relationship from both ABS and PRO. This means that an increase in liquidity in the UK (the US) increases liquidity in the US market (the UK) which is consistent with the results obtained from the GARCH-M model except the spillover effect (ABS) from the US to the UK. It also obtains a positive two way relationship between the UK and Hong Kong for both ABS and PRO. These two markets Granger cause each other. However, the GARCH-M model does not provide similar results. For instance, the study finds a spillover effect from the UK to Hong Kong only with ABS while it shows a spillover effect from Hong Kong to the UK with PRO only. Between the UK and Japan, the UK Granger causes Japan while Japan does not Granger cause the UK which is an opposite result when compared with the result obtained from the GARCH-M model. Between the UK and China, there is a two way Granger causality relation for ABS only. When it uses PRO, China Granger causes the UK while the UK does not Granger cause China. Again when it compares findings between Granger-causality test and the GARCH-M, there is a consistent spillover effect from the UK to China (ABS) and from China to the UK (PRO). Finally, the study shows a positive two way relationship between the UK and Korea for PRO while it does not show any Granger causal relation between the UK and Korea for ABS. Generally, it confirms consistent spillover effects for all countries from both tests (GARCH-M model and Granger-causality test) except for the UK & Japan group.

Table 3.23

Granger Causality Tests and GARCH-M for all countries

	Granger Causality Test (H_0: A does not →B)		GARCH-M (The Coefficient of X_{t-1})	
	ABS	PRO	ABS	PRO
UK → US	5.5863 (0.0039)***	2.3473 (0.0962)*	0.00001 (0.0000)*	-1.3E-06 (0.0677)*
US → UK	4.6948 (0.0094)***	7.6527 (0.0005)***	0.1949 (0.4838)	9.67E-06 (0.0867)*
UK → JAPAN	4.1403 (0.0162)**		-0.00004 (0.9487)	
JAPAN → UK	0.0586 (0.9430)		0.0430 (0.0932)*	
UK → HK	25.0161 (0.0000)***	7.0884 (0.0009)***	0.00013 (0.0612)*	1.23E-07 (0.2511)
HK → UK	5.2155 (0.0056)***	2.5628 (0.0776)*	13.6107 (0.7261)	1.72E-05 (0.0783)*
UK → CHINA	42.0131 (0.0000)***	0.8410 (0.4316)	2.3E-07 (0.0000)***	0.0201 (0.0000)***
CHINA → UK	41.6116 (0.0000)***	2.9476 (0.0530)*	2.5249 (0.6509)	6.4E-09 (0.0005)***
UK → KOREA	0.8071 (0.4465)	14.573 (0.0000)***	0.0001 (0.7406)	1.72E-11 (0.0242)**
KOREA → UK	0.4192 (0.6577)	3.4682 (0.0316)*	-0.5954 (0.0183)**	0.0233 (0.0009)***

The table shows Granger causality tests and the GARCH-M model (tests of spillovers) between UK and other countries which include US, Japan, Hong Kong (HK), China and Korea. We test the null hypothesis that liquidity shock in country A does not Granger cause the liquidity shock in country B. We report the χ^2 and p value (in parenthesis) for each test. From the GARCH-M model, we report the coefficient of X_{t-1} and p value (in parenthesis) for each test. *, **, *** indicate statistically significant at 10%, 5%, and 1% respectively.

3.6.1. THE EFFECT OF FOREIGN EXCHANGE RATE

Up to now this study examines liquidity volatility spillover effects between the selected countries. This study uses a single currency. The local currency is converted into British pound. In order to address the effect of foreign exchange rate on liquidity volatility spillover effect, it repeats all tests with local currency for the 6 countries (not presented). The study finds that there are no spillover effects in the UK-US group, the UK-Japan group, and UK-Korea group while it shows strong spillover effects in the UK-China group and the UK-Hong Kong group.

3.7. CONCLUSION

This empirical study investigates liquidity volatility spillovers between the U.K. and East Asian stock markets (Japan, China, Hong Kong, and Korea) and between the U.K. and the U.S. from 2006 to 2010 adopting GARCH(1,1)-M model by Hamao, Masulis, and Ng (1990). This study presents evidence that liquidity volatility for all countries is high and persistent. This study also confirms the existence of liquidity volatility spillover effects. It shows significant spillover effects between the U.K. and the U.S. As it uses different measures of liquidity, results are mixed for each country, for instance, it finds a spillover effect from the UK to Hong Kong with ABS but there is no spillover effect when it uses PRO. However, Granger causality tests clearly show that there is spillover effect between the UK and Hong Kong. Also spillover effects between the UK and China are found in both directions. The study finds spillover effects between the UK and Korea but it is weak. Finally, the existence of liquidity spillover effects between the U.K. and Japan are rather ambiguous.

Generally, it finds significant spillover effects in the UK-US group, the UK-China group and the UK-Korea group. This is a consistent result from both tests (GARCH-M and Granger Causality Test). The evidence suggests that the risk associated with market making between countries, which are in different continents, is strongly correlated. As the conventional market contagion theory in the literature says that the risk is spreading due to the increased interdependency of the global stock market, this study supports it by providing the evidence which shows significant spillover effects between the UK and selected Asian countries.

This empirical study has some limitations which stem from unavailability of data and non-synchronised trading hours. Hamao, Masulis, and Ng (1990) use open to close and close to open stock price data set in order to avoid issues arising from non-synchronized trading hours. However, daily opening bid and ask price is not available, so the study uses close to close price data set. Finally, the financial crisis period (2007-2009) is included in the sample, but the study could not test liquidity spillover effect during the normal and crisis period separately due to the small sample size. This small sample size causes the failure of meeting positive coefficient requirement for the GARCH-M model.

CHAPTER 4: ON THE PRICING OF COMMONALITY ACROSS VARIOUS LIQUIDITY PROXIES IN THE LONDON STOCK EXCHANGE

4.1 INTRODUCTION

Empirical evidence is mixed regarding the relationship between liquidity and stock returns. Amihud and Mendelson (1986) investigate the influence of liquidity on stock returns on New York Stock Exchange (NYSE) stocks over the period 1961-1980. They use bid-ask spread as a liquidity measure which shows a strong positive relationship with stock returns. Eleswarapu and Reinganum (1993), however, argue that a positive relationship between liquidity and returns exists in January only and no such a relationship is found in other months. Moreover, different conclusions are drawn when different liquidity measures are used such as turnover and volume. Brennan et al (1998) find a negative relation between returns and trading volume for both NYSE and NASDAQ stocks while Jun, Marathe, and Shawky (2003) find a positive correlation between stock returns and market liquidity (volume based liquidity proxies). There are also different findings based on turnover. Datar, Narayan, and Radcliffe (1998) use turnover ratio as a liquidity measure and find a negative correlation between liquidity and returns for NYSE stocks. Similarly, Dey (2005) support a negative relation between returns and turnover but this relationship is valid for developed markets only as the emerging markets show a positive relationship.

Since liquidity is not a simple concept to explore and not directly observable, a number of liquidity measures have been proposed; Bid-Ask Spread (Amihud and Mendelson, 1986), Turnover and Volume (Brennan, Chordia, and Subrahmanyam, 1998), Price impact (Amihud, 2002 and Korajczyk & Sadka, 2008), and Zero return (Lesmond, 2005; Bekaert, Harvey, and Lundblad, 2007). Even though, these liquidity proxies are widely used in asset pricing research, there is no such thing as a superior proxy that is able to capture all facets of liquidity. Chai, Faff, and Gharghori (2010) emphasize the multi-dimensional characteristics of liquidity by looking at relations between six liquidity proxies and between the liquidity proxies and stock characteristics in the Australian stock market. The liquidity proxies employed are proportional spread, turnover, the Amihud measure, zero returns, returns reversal measure, and turnover (adjusted by number of zero daily volume)[23]. Additionally, they use stock prices, trading volume, and volatility as stock characteristics. They report low correlations between adopted liquidity proxies which imply that the proxies used represent different dimensions of liquidity. Also they point out that the turnover measure shows a rather different pattern compared to all other liquidity proxies and there is no evidence that the return reversal measure depends on stock characteristics. Brown, Du, Rhee and Zhang, (2008) show that the main determinants of commonality in liquidity are different for each market because each of the markets they look into has different trading mechanisms and the traders' behaviour is different. These two fundamental differences (dimensions of proxy

[23] Return reversal measure is obtained by running the following OLS regression: $r^{e}_{i,t+1} = \gamma_0 + \gamma_1 r_{i,t} + \lambda\left[\mathrm{sign}\left(r^{e}_{i,t}\right) \times$ voli,t+εi,t where ri,t+1e is the excess return with respect to the value-weighted market index return, ri,t is the return for firm I on day t, $\mathrm{sign}\left(r^{e}_{i,t}\right)$ is the sign of the excess return with respect to the market index return for firm I on day t, and $\mathrm{vol}_{i,t}$ is the trading volume. They estimate Zero return following Lesmond et al (1999). Finally, turnover-adjusted number of zero daily volume is defined as: $\mathrm{LM}_{i,t} = [\mathrm{NoZV}_{i,t} + \frac{\frac{1}{\mathrm{turnover}_{i,t}}}{\mathrm{Deflator}}] \times \frac{21}{\mathrm{NoTD}_t}$ where $\mathrm{NoZV}_{i,t}$ is the number of zero daily trading volume, $\mathrm{turnover}_{i,t}$ is stock turnover, and NoTD_t is the total number of trading days in the market in month t and the deflator is set to 480,000.

and market structure) could lead to different conclusions. Therefore, it is very crucial to analyse markets using a type of liquidity measure which captures as many facets of liquidity as possible in order to reconcile the different relations observed.

In order to capture the different facets of liquidity proxies, Korajczyk and Sadka (2008), (hereafter K&S), investigate commonality in liquidity using a latent factor model. K&S obtain common factors from different liquidity proxies. They apply an asymptotic principal components method to estimate a measure of systematic liquidity risk across a set of eight measures for NYSE-listed stocks. They obtain within-measure and across measure common factors. They investigate relations between market-wide within-measure factors and across-measure using canonical correlation. They show that there is commonality across assets for each measure of liquidity. They also find common factors across all eight liquidity measures and that liquidity shocks are contemporaneously correlated with return shocks for the US. Since the across measure is correlated with various liquidity proxies and it is confirmed as a priced factor in the US stock market, this study expects that the across-measure may be a better measurement of liquidity in terms of its accuracy because it contains multi-dimensional characteristics of liquidity. The study apply K&S's (2008) framework to investigate if their findings apply to other markets as well such as the UK. In particular we investigate: (1) the degree of commonality in liquidity for the UK stock market for each measure of liquidity (within-measure) and systematic common liquidity factor (across-measure), (2) persistence of liquidity shocks for within-measures and the across-measure (3) the lead-lag relation among all liquidity measures and predictability between liquidity shocks and stock returns (4) and if systematic liquidity risk is a priced factor in the UK.

The finding of this chapter shows strong liquidity commonality for the UK which is consistent with the result of Galariotis & Giouvris (2007 & 2009) and Gregoriou, Ioannidis and Zhu (2011). Also, this study shows that changes in liquidity measures are correlated. They are also contemporaneously correlated with returns in the UK stock market. Additionally, the UK stock market shows relatively weaker persistence of liquidity stocks compared to the K&S (2008) findings. Shocks to returns can predict future liquidity levels but returns cannot be predicted by past liquidity shocks in this empirical study. It obtains relatively weaker evidence regarding the pricing of the across-measure liquidity in the UK. The remainder of this paper is organized as follows. Section 4.2 present the literature review and section 4.3 describes the data and the measures of liquidity proxies and methodology. Section 4.4 analyzes findings and concluding in section 4.5.

4.2. LITERATURE REVIEW

4.2.1. COMMONALITY IN LIQUIDITY.

Several studies identify systematic components between measures of liquidity which has evolved over time as an important concern to many investors and markets. Chordia, Roll, and Subrahmanyam (2000) find evidence of systematic components in the market and in the industry in daily bid-ask spreads and quoted depth. Pastor and Stambaugh (2003) use AMEX and NASDAQ stock to look into commonality. The liquidity measure used in the study is order flow which shows significant commonality across stocks. Also smaller stocks are less liquid and are more sensitive to market liquidity and stocks sensitive to market liquidity tend to have higher expected returns. Further investigation by Kamara, Lou, and Sadka (2008) shows that commonality in liquidity has increased over time for large firms and declined for small firms. They point out institutional investing and index trading as the main source of commonality in liquidity and it is more prevalent in large stocks than in small stocks. All the above studies concentrated on the U.S. market.

There are some papers focusing on the U.K. and other markets. Galariotis & Giouvris (2007) look into commonality in the UK market across different trading regimes using FTSE100 and FTSE250 stocks. They find that commonality is quite strong for FTSE100 stocks at individual and portfolio level, while for the FTSE250 it is strong only at portfolio level. Overall commonality is on average similar across trading regimes, irrespective of the nature of the provision of liquidity. Gregoriou, Ioannidis and Zhu (2011) apply the methodology of Chordia, Roll, and Subrahmanyam (2000) for the UK market and confirm the existence of commonality in liquidity in the UK market before and after the financial crisis. They use relative and effective bid-ask spreads as proxies for liquidity. Moreover, a few other studies have attempted to explore systematic liquidity risk and its relation to expected returns for other countries. Commonality is also present in smaller markets. In particular Galariotis & Giouvris (2008) show that commonality is also present in smaller markets such as the Athens Stock exchange which has more than 50% of its stocks owned by international investors, 77% of which are institutional ones, but it is not priced and not as strong as in the

UK and US, while it comes in waves and appears more pertinent in high capitalization companies.

These empirical studies provide strong evidence of commonality in liquidity. Also the level of commonality in liquidity is varying over time based on market conditions.

4.2.2. INCONCLUSIVE EMPIRICAL FINDINGS REGARDING THE RELATION BETWEEN LIQUIDITY AND RETURNS

Eleswarapu and Reinganum (1993) apply the model of Amihud and Mendelson (1986) in NYSE using an extended sample from 1961 to 1990. They find that a positive relationship between liquidity (bid-ask spread) and returns exists only in January and no such a relationship is found in other months. Different conclusions are drawn when different liquidity measures are used such as turnover and volume. Brennan, Chordia, and Subrahmanyam (1998) find a negative relation between returns and trading volume for both NYSE and NASDAQ stocks for the period January 1966 to December 1995. There is also mixed findings using turnover as a liquidity measure. Datar, Narayan, and Radcliffe (1998) examine the liquidity (turnover)-return relationship for all non-financial firms on the NYSE from 1962 through 1991. They find a strong negative relation between stork returns and liquidity. Dey (2005) supports a negative relation between turnover and returns using 48 stock exchanges (22 exchanges from Europe, 7 exchanges from North America, 13 exchanges from Asia/Pasific, 5 exchanges from South America and 1 exchange from Africa) from 1995 until 2001. They find that turnover is significant for emerging market portfolios only while it is insignificant for developed market portfolios but volatility is significant for developed market portfolios only. Thus they conclude that “The intuition behind these results is that in developed markets, which are already liquid markets, liquidity is not a concern for investors, price volatility is; but in emerging markets many of which are thin and lack liquidity, liquidity risk is the principal source of risk” p.63. Similarly, Jun, Marathe, and Shawky (2003) investigate the relationship between stock returns and liquidity measures such as turnover ratio, trading volume, and turnover-volatility ratio for 27 emerging markets from January 1992 until December 1999. They show that stock returns in emerging countries are positively correlated with the liquidity measures. This positive correlation holds in both cross sectional and time-series analysis (reporting average regression coefficient and adjusted R^2 values). They argue that “if emerging markets are not fully integrated with the global economy, then lack of liquidity will not function as a risk factor, and thus cross-sectional returns will not necessarily be lower for liquid markets” p.3. Hence, a potential explanation of this positive relation in emerging markets could be the low degree of global integration.

4.2.3. MULTI-DIMENSIONAL CHARACTERISTICS OF LIQUIDITY AND DETERMINANTS.

Since liquidity is not a simple concept to explore and not directly observable, different liquidity proxies are widely used in asset pricing research. However, there is no such thing as a superior proxy. Moreover, Brown, Rhee, and Zhang (2008) argue that the pattern or behaviour of liquidity risk is different between markets and the main determinants of value premium (difference between the average return of a value portfolio and that of a growth portfolio) are different for each market. They find that low liquidity, high price, and large market cap are the main sources of value premium in Singapore while low liquidity, low price, and small market cap are the main determinants of value premium in Hong Kong. More recently, Karolyi, Lee, and Dijk (2012) use 40 countries as their sample to investigate the effect of demand side factors (trading behaviour of investors, investor sentiment, and incentives to trade individual securities) and supply side (funding liquidity) factors on commonality in liquidity (captured by the Amihud-measure). They show that the degree of commonality in liquidity varies across the 40 countries under examination and over time. They also find that demand side factors are the main determinants of commonality in liquidity in many of the countries under examination (using cross-sectional regression and reporting the average of R^2 from 40 countries) while funding liquidity (supply-side factor) is the main driver of commonality in liquidity in the US during the recent crisis.

4.2.4 SYSTEMATIC LIQUIDITY RISK AND PRICING

Systematic liquidity risk and pricing is another strand of literature which has received a lot of attention. Martinez, Nieto, Rubio, and Tapia (2005) analyse the Spanish stock market following Pastor and Stambaugh (2003). They estimate a market-wide factor which is defined as the difference between the returns of stocks which are highly sensitive to changes in liquidity and the returns on stocks with low sensitivity to changes in liquidity. Their findings show that systematic liquidity risk is priced in the Spanish stock market. Lam and Tam (2011) look into the Hong Kong stock market using the Fama-French four factor model and confirm that liquidity is a priced factor in the Hong Kong market however momentum is not priced. More importantly, the level of commonality in liquidity tends to vary significantly over time in emerging markets such as China, India, and Malaysia depending on market conditions: boom or bust.[24]

Considering the well established presence of commonality in liquidity (see section 4.2.1), the inconclusive evidence regarding the relation between liquidity and returns (see section 4.2.2), the different facets of liquidity (see section 4.2.3) and the more recent trend in testing whether liquidity risk is priced (see section 4.2.4), the study examines all those issues concentrating on the London stock exchange using the K&S (2008) methodology.[25]

4.3 DATA AND METHODOLOGY

4.3.1 DATA SOURCES AND LIQUIDITY PROXIES

This chapter focuses on the UK market (London Stock Exchange-listed stocks) using FTSE100 and FTSE250 from March 1999 until December 2011. It uses daily data to construct monthly time series liquidity variables. All the data used in this paper is obtained from Datastream. Before creating liquidity proxies, negative bid-ask spreads and non trading days are eliminated. After filtering the data set and synchronising individual firms' trading days, the final data set contains 186 companies from FTSE100 and FTSE250. Then, a monthly time

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[24] Please see Karolyi et al. (2012).

[25] In an earlier study Hasbrouck and Seppi (2001) examine Dow Jones 30 stocks using Principal Component Analysis and extract common factors across returns, order flows and liquidity such as bid ask spreads, depths, and quote-slope measures. They provide evidence for the existence of market-wide common factors in order flows and stock returns but liquidity measures such as spread, log size, and quoted depth show weak or little evidence of commonality

series of four different measures of liquidity is constructed which are used widely in the literature.

1. Amihud measure: the daily average of absolute value of return divided by Pound (£) volume for asset i in month t.

$$A_{i,t} = \frac{1}{D}\sum_{d=1}^{D}\frac{|r_{i,d}|}{£vol_{i,d}} \quad (4.1)$$

Where $r_{i,d}$ is the absolute return on asset i on day d of month t, $£\,vol_{i,d}$ is the £ volume traded in asset i on day d of month t, and D is the number of trading days in month t. Simply, the absolute return is divided by the trading volume for each day and then average over a month. This proxy is based on the measure proposed in Amihud (2002) and it requires asset i to have at least 15 days observation in month t to include in the sample. In order to remove the downward trend in the series, $A_{i,t}$ is rescaled by the ratio of market capitalization of FTSE100 market index at *t*-1 and at a reference date (31/3/1999).

2. Absolute bid-ask spread: the daily absolute ask price minus bid price for asset *i* in month *t*.

$$ABSP_{i,t} = \frac{1}{n_{i,t}}\sum_{j=1}^{n_{i,t}} Ask_{i,j} - Bid_{i,j}\ , \quad (4.2)$$

This liquidity proxy is estimated as follows: it takes the difference between ask and bid price for each quote and then obtain monthly estimation as a simple average through the month.

3. Proportional Spread: the quoted percentage spread, measured for each trade as the ratio of the quoted bid-ask spread and the mid-point of bid-ask spread.

$$\mathrm{APSP}_{i,t} = \frac{1}{n_{i,t}} \sum_{j=1}^{n_{i,t}} \frac{\mathrm{Ask}_{i,j} - \mathrm{Bid}_{i,j}}{m_{i,j}} \tag{4.3}$$

Where the mid-point is estimated as follows: $m_{i,j} = (\mathrm{Ask}_{i,j} + \mathrm{Bid}_{i,j})/2$. $\mathrm{Ask}_{i,j}$ and $\mathrm{Bid}_{i,j}$ are the closing ask and bid quotes prevailing at the time of the jth trade of asset *i* in month *t*, and $n_{i,t}$ is the number of eligible trade of asset *i* in month *t*.

4. Turnover: the ratio of monthly volume divided by shares outstanding.

$$\mathrm{TO}_{i,t} = \frac{\sum_{j=1}^{d_t} \mathrm{Vol}_{i,j}}{\mathrm{SO}_{i,t}} \tag{4.4}$$

Where SO_t is share outstanding at the end of month *t* and $\mathrm{Vol}_{i,j}$ is the volume of asset *i*.

4.3.2 METHODOLOGY

Following Korajczyk and Sadka (2008), the model uses principal components analysis to extract and analyze common factors in returns and various liquidity proxies. Principal components analysis (hereafter PCA) explains the variance-covariance structure of the underlying data using linear combinations of the original variables. In PCA one must look for a maximum, because the first component has to extract maximum variance from the set of variables and each next component is also at maximum from the remaining variance, under two restricting conditions which are following:

1. The components have to be perpendicular (orthogonality).

2. The first component has to extract as much variance as possible from the original variables, the second component as much as possible from the remaining variance, etc.... until all variance is used up (principal axis method).

Liquidity variables are standardized by the sample mean and standard deviation of the cross-sectional average liquidity measures, using all available data prior to month t.

$$L_{j,t}^{i} = (L_{j,t}^{i*} - \hat{\mu}_{t-1}^{i})/\hat{\sigma}_{t-1}^{i} \tag{4.5}$$

Where $L_{j,t}^{i*}$ is the $n \times T$ matrix of observations on the i^{th} liquidity measures (superscript i = 1,2,3,4). Define $\hat{\mu}_{t-1}^{i}$ and $\hat{\sigma}_{t-1}^{i}$ to be the time-series mean and standard deviation of liquidity measure i, estimated from the data sample up to time t-1. Let $L_{j,t}^{i}$ be a standardized liquidity variable for security i at time t. for example, in this case, $L_{j,t}^{i}$ could represent standardized Amihud, bid-ask spread, proportional spread, and turnover.

Given a number of securities N and T periods, let $L_1, L_2, \dots\dots, L_n$ be vectors of length T such that $L_i' = \left[L_{i,1}, L_{i,2}, \dots\dots L_{i,t}\right]$, let L be the matrix $[L_1, L_2, \dots\dots, L_n]$, and let V be the covariance matrix of L.

Consider a linear combination of these variables defined as follows

$$C_j = \gamma_j' L = \gamma_{1,j} L_1 + \gamma_{2,j} L_2 + \cdots + \gamma_{n,j} L_n \tag{4.6}$$

The variance of C_j is defined as $\gamma_j' V \gamma_j$. If γ_j is chosen to maximize the variance of C_j, then C_j is referred to as the first principal component. The second principal component is linear combination that maximizes the variance of C_j subject to the condition that is uncorrelated with first principal component. As many as N principal components can be extracted in this manner conditional on each being uncorrelated with all previously extracted principal components. Together, the N principal components provide the same information as the original N variables. In other words, $\sum_{j=1}^{N} \sigma_i^2 = \sum_{j=1}^{N} \mathrm{var}(L_j)$. The most useful feature of PCA is that the principal components can be interpreted as functions of the eigenvalue and eigenvector of V. In particular, the variance of the first principal component $\lambda_1 = \mathrm{var}(C_1)$, equals the first eigenvalue of V and the coefficient vector, γ_1, equals the first eigenvector. Thus this study uses eigenvalues as a measure of the strength of commonality.

The first three principal components are extracted for each liquidity measure. In order to explore the strength of commonality across assets for each liquidity measure, it estimates a time-series regression for each individual stock's liquidity on the extracted factors. The R^2 of regression and p-value of the factor loadings are reported.

The regression estimated is

$$L_{j,t}^{i} = B_j^i \hat{F}_t^i + \hat{\varepsilon}_{j,t}^{i} \qquad (4.7)$$

Where $\hat{F}_t^i$ is the $K \times 1$ vector of factor estimates for month t. The cross-sectional average of R^2 and adjusted R^2 values for *K=1,2,3* are reported in table 1and $L_{j,t}^{i}$ is standardized liquidity variable.

Additionally, it estimates systematic factors across all four liquidity measures defined as the across-measure factor. This study uses changed signs of these extracted factors as K&S (2008) refer to liquidity rather than illiquidity. This implies that the high value of the common factor indicates high level of liquidity.

4.4 EMPIRICAL RESULTS AND ANALYSIS

4.4.1 DEGREE OF COMMONALITY

In order to illustrate the degree of commonality, the study reports the R^2 value and the adjusted R^2 value in table 4.1. According to Corwin and Lipson (2011), if there were no common components in the original variables, each eigenvalue would equal one and the first three principal components would explain 3/N of the total variation. This section reports eigenvalues of the first three components and the percentage of variance explained by the first three eigenvalues. While Corwin and Lipson (2011) examine the US market and report an eigenvalue of 8.43 for returns and the first three principal components explain approximately 11.7%, this study obtains an eigenvalue of 57.82 for returns and the first three components explain 39% of variance. For liquidity, the percentage of explained variance ranges from 21% to 61%. This huge difference in eigenvlaues between this study and Corwin and Lipson (2011) is due to the size of sample. For instance, Corwin and Lipson (2011) extract common factors from 100 companies while this study uses 186 companies to extract common factors.

The table 4.1 also shows the average R^2 and adjusted-R^2 values for 1, 2, and 3 factors. For all liquidity variables, R^2 values increase as it increases the number of factors and the value of adjusted R^2 is slightly smaller than R^2. For a 1-factor model, the R^2 ranges approximately from 16% to 30% and returns have the highest R^2 value (30%) and the Amihud measure shows the smallest R^2 values (16%). For a three-factor model, returns show the highest R^2 values (35%) while absolute spread has the lowest level of commonality (26%). These results are consistent with the results of Chordia, Roll, and Subrahmanyam (2000), who find commonality among quoted and effective spreads. Also the degree of commonality (R^2 value) for some variables is very similar and some of them are even greater than those reported for the US market by K&S (2008). Based on a three factor model, for instance, it shows commonality of 35% for returns while K&S report 23% for returns. The level of commonality in turnover in the study is much greater than K&S's finding (33% and 23% respectively). However, proportional spread in the study shows a commonality of 17% while it is 25% in the K&S study. The Amihud measure in the K&S study shows greater commonality (44%) than the Amihud measure in the study (32%).

Table 4.1: Diagnostics of within-measure common factors

This table reports the degree of commonality across assets for each liquidity measure. Common factors are extracted separately for returns and different measures of liquidity using Principal Component Analysis. The liquidity proxies used are: Amihud (2002), defined as the monthly average of daily absolute value of return divided by pound volume and it is rescaled by market capitalization; Absolute bid-ask spread, measured as the difference between Ask and Bid price; Proportional bid-ask spread, measured as the absolute bid-ask spread divided by bid-ask min-point; Turnover defined as the ratio of monthly volume over shares outstanding. Before extracting common factors and regression analysis, we normalized all liquidity measures individually by its mean and standard deviation calculated up to the prior month (with at least five prior monthly observations). We regress for each stock's liquidity on the three extracted factors ($L^i_{j,t} = B^i_j \hat{F}^i_t + \hat{\varepsilon}^i_{j,t}$). Then we save the R^2 and the adjustedR^2. Where $\hat{F}^i_t$ is the k×1 vector of factor estimated for month t. The table presents the average R^2 and the average adjusted-R^2 from the regression associated with one, two, and three factors. The sample includes 186 companies from FTSE100 (71 firms) and FTSE250 (115 firms) between March 1999 and December 2011 (154 months). All the data is obtained from Datastream.

Degree of commonality					Eigenvalues and explained variance (%)		
Variable	Statistic	Factor 1	Factor 2	Factor 3	1st	2nd	3rd
Return	R^2	0.302	0.328	0.354	57.823	9.914	6.203
	Adjusted R^2	0.298	0.319	0.341	(31.088%)	(36.418%)	(39.753%)
Amihud	R^2	0.169	0.295	0.322	50.053	22.367	10.826
	Adjusted R^2	0.163	0.286	0.309	(21.563%)	(38.935%)	(44.756%)
Absolute Spread	R^2	0.214	0.240	0.256	48.68	18.495	12.984
	Adjusted R^2	0.208	0.230	0.242	(25.099%)	(35.043%)	(42.024%)
Proportional Spread	R^2	0.177	0.258	0.305	78.752	21.527	14.378
	Adjusted R^2	0.172	0.248	0.291	(42.340%)	(53.913%)	(61.643%)
Turnover	R^2	0.239	0.303	0.326	59.144	9.355	5.978
	Adjusted R^2	0.289	0.294	0.313	(31.798%)	(36.828%)	(40.041%)

4.4.2 THE TIME SERIES PROPERTIES OF SYSTEMATIC LIQUIDITY FACTORS

This study examines the persistence of liquidity factors in this section. First, it plots the autocorrelation function of the first factor of each measure expecting that the autocorrelation exhibited for all four liquidity measures will be persistent.

Figure 4.1 plots the autocorrelation function of the first principal component for the Amihud, Absolute spread, Proportional spread, and Turnover. These first factors are extracted from liquidity variables separately. As it can see from figure 4.1, the Amihud measure exhibits relatively weak autocorrelation while Absolute spread, Proportional spread and Turnover factors exhibit stronger autocorrelation.

Following K&S (2008), the model fits AR(2) models to the liquidity factors and apply impulse response functions to estimate the persistence of liquidity shocks 6 and 12 months afterwards (see table 4.2). The coefficient of AR(1) is statistically significant for all measures while the coefficient of AR(2) obtained for proportional spread, turnover, and across-measure is statistically insignificant. All of the liquidity variables show stronger persistence of shocks at 6 months compared to shocks at 12 months. The strongest persistence occurs for turnover (24% and 19% at 6-months and at 12-month respectively) followed by absolute spread which shows a persistence level of 22% at 6 months and 16% at 12 months. The Amihud measure shows persistence level of 16% at 6 months which is reduced to 4.5% at 12 months. Proportional spread presents the weakest persistence at 6 months while Across-measure exhibits the weakest persistence at 12 months. These results show that UK stock market presents milder persistence of liquidity shocks compared to the findings of K&S (2008) for the US. This could be because of the smaller sample. The impulse response functions are presented in figure 4.2. The Amihud measure, absolute spread and turnover show a huge decline in the first two months and then decaying gradually while proportional spread and across measure liquidity declines smoothly over 12 months. In terms of persistence, figure 4.2 clearly shows that turnover is the strongest one as mentioned before.

Figure 4.1: Autocorrelations of liquidity factors

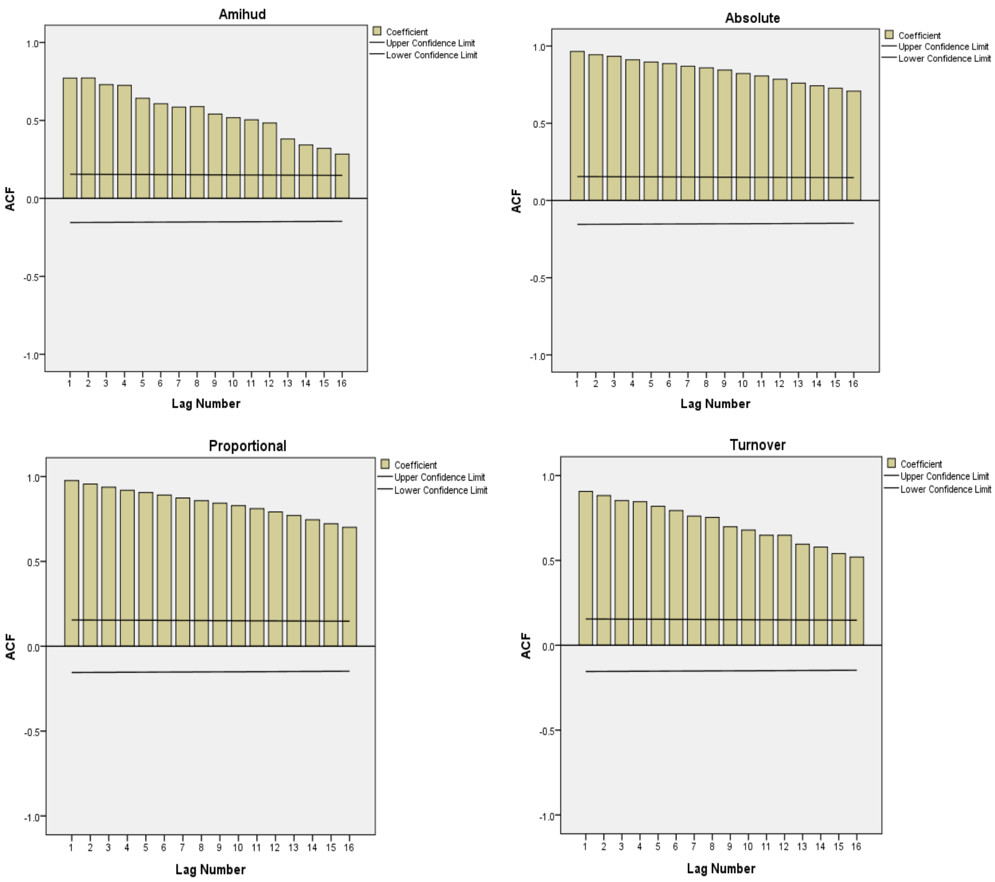


Fig.4.1. Common factors are extracted separately for different measures of liquidity using the PCA method. We analyse liquidity measures only which are: Amihud (2002) measure, defined as the monthly average of daily absolute value of return divided by Pound volume; Absolute spreads is measured as ask price minus bid price; proportional spreads, measured as absolute spread is divided by mid-quote where mid-quote is equal to (bid price + ask price)/2; turnover, defined as the ratio of monthly volume and shares outstanding. The figure plots the autocorrelation function of each of the first principal components. All liquidity variables are monthly observation and the sample includes 186 companies from FTSE100 (71 firms) and FTSE250 (115 firms) for the period March 1997 until Decmber 2011 (154 months). All the data is obtained from Datastream.

Table 4.2: Persistence of aggregate liquidity

We extracted within-measure factors separately for different measures of liquidity using the PCA method and across measure common factors are extracted for all the liquidity measures jointly. Then we fit the AR(2) model for each first principal common factor in order to demonstrate the persistence of liquidity shocks. The 6-month and 12-month values of the impulse response function applied to each time series are reported. The liquidity proxies used are: Amihud (2002), defined as the monthly average of daily absolute value of return divided by pound volume and it is rescaled by market capitalization; Absolute bid-ask spread, measured as the difference between Ask and Bid price; Proportional bid-ask spread, measured as the absolute bid-ask spread divided by bid-ask min-point; Turnover defined as the ratio of monthly volume over shares outstanding. Before extracting common factors and regression analysis, we normalized all liquidity measures individually by its mean and standard deviation calculated up to the prior month (with at least five prior monthly observations). AR(1) and AR(2) in the table represents the coefficient of first-order and second-order autocorrelation respectively. We report p-value in the bracket. The sample includes 186 companies from FTSE100 (71 firms) and FTSE250 (115 firms) between March 1999 and December 2011 (154 months). All the data is obtained from Datastream.

Persistence of liquidity variables				
Variable	AR(1)	AR(2)	Shock after 6 months	Shock after 12 months
Amihud	0.5282 (1.05E-09)	0.2312 (0.0057)	0.1576	0.0453
Absolute	0.5996 (2.28E-12)	0.2768 (0.0005)	0.2240	0.1233
Proportional	0.8345 (7.63E-19)	-0.0370 (0.6028)	0.0759	0.0181
Turnover	0.6158 (4.41E-13)	0.3354 (3.30E-05)	0.2434	0.1950
Across measure	0.7006 (1.30E-14)	0.0280 (0.7336)	0.1072	0.0174

Figure 4.3 shows residuals from an AR(2) specification for each of the individual liquidity measures and the systematic factor (the across-measure). The factors are signed so that positive changes are associated with increasing liquidity. From figure 4.3, it presents different behaviour of five liquidity proxies over time. Firstly, absolute and proportional spread shows relatively mild volatility overall and the most volatile period of time is in 2000 (dot com bubble) while the Amihud measure is capturing both the dot com bubble crisis (in 2000) and recent financial crisis (in late 2007). Turnover shows the most consistent level of volatility over the whole sample period. The across measure which has been extracted from these four liquidity proxies shows that the most volatile period is between 2000 and 2001 and it is diminishing gradually. From figure 4.3, it can also see that each measure is capturing a different pattern of liquidity.

Fig 4.2: Impulse response of Liquidity proxies

We report the graph from the impulse response function of the first common factor which is extracted separately for different measures of liquidity measures of liquidity using the PCA method. Additionally, we extract across-measure common factors for all the liquidity measures jointly. We fit the AR(2) model for each first principal common factor. The liquidity proxies used are: Amihud (2002), defined as the monthly average of daily absolute value of return divided by pound volume and it is rescaled by market capitalization; Absolute bid-ask spread, measured as the difference between Ask and Bid price; Proportional bid-ask spread, measured as the absolute bid-ask spread divided by bid-ask min-point; Turnover defined as the ratio of monthly volume over shares outstanding. Before extracting common factors and regression analysis, we normalized all liquidity measures individually by its mean and standard deviation calculated up to the prior month (with at least five prior monthly observations). The sample includes 186 companies from FTSE100 and FTSE250 between March 1999 and December 2011 (154 months). All the data is obtained from Datastream.

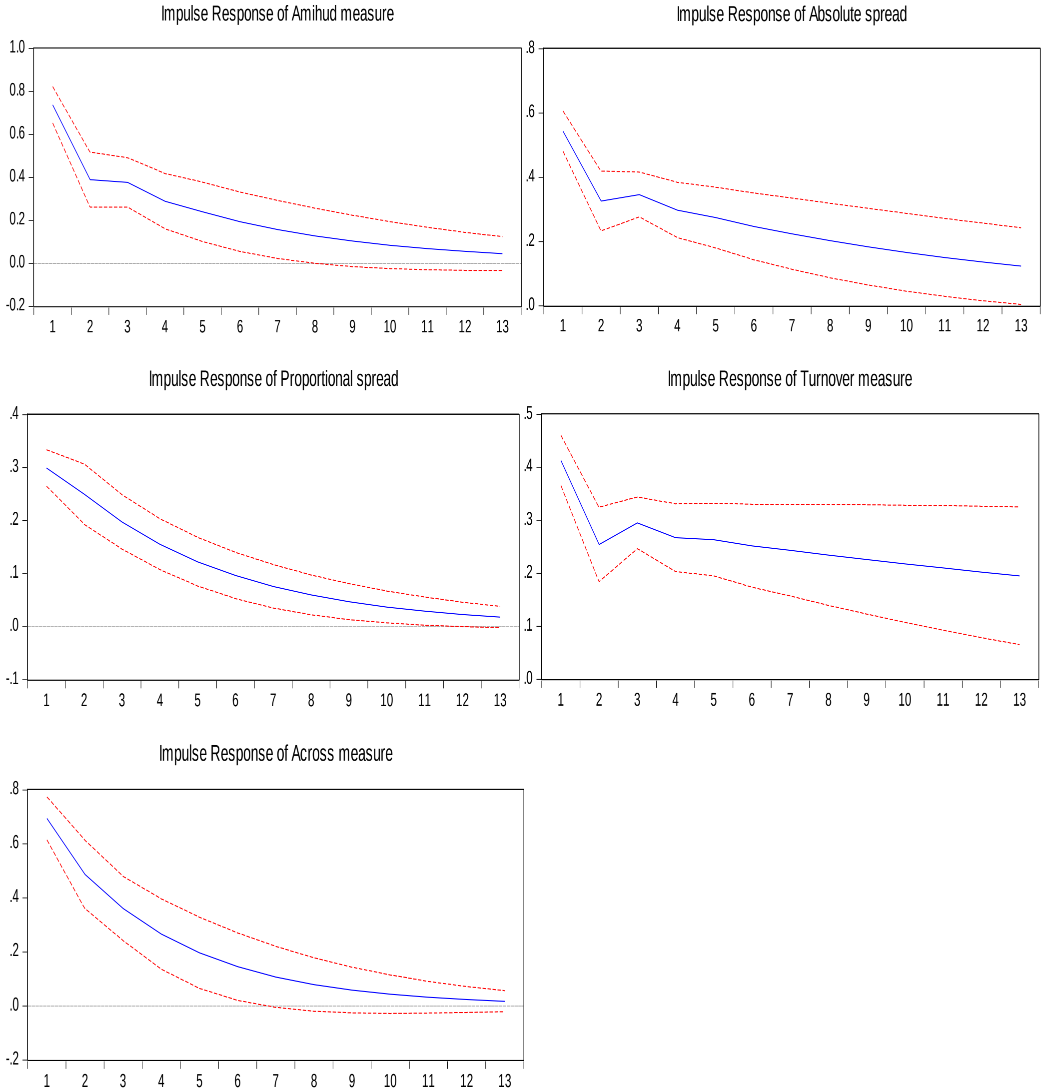
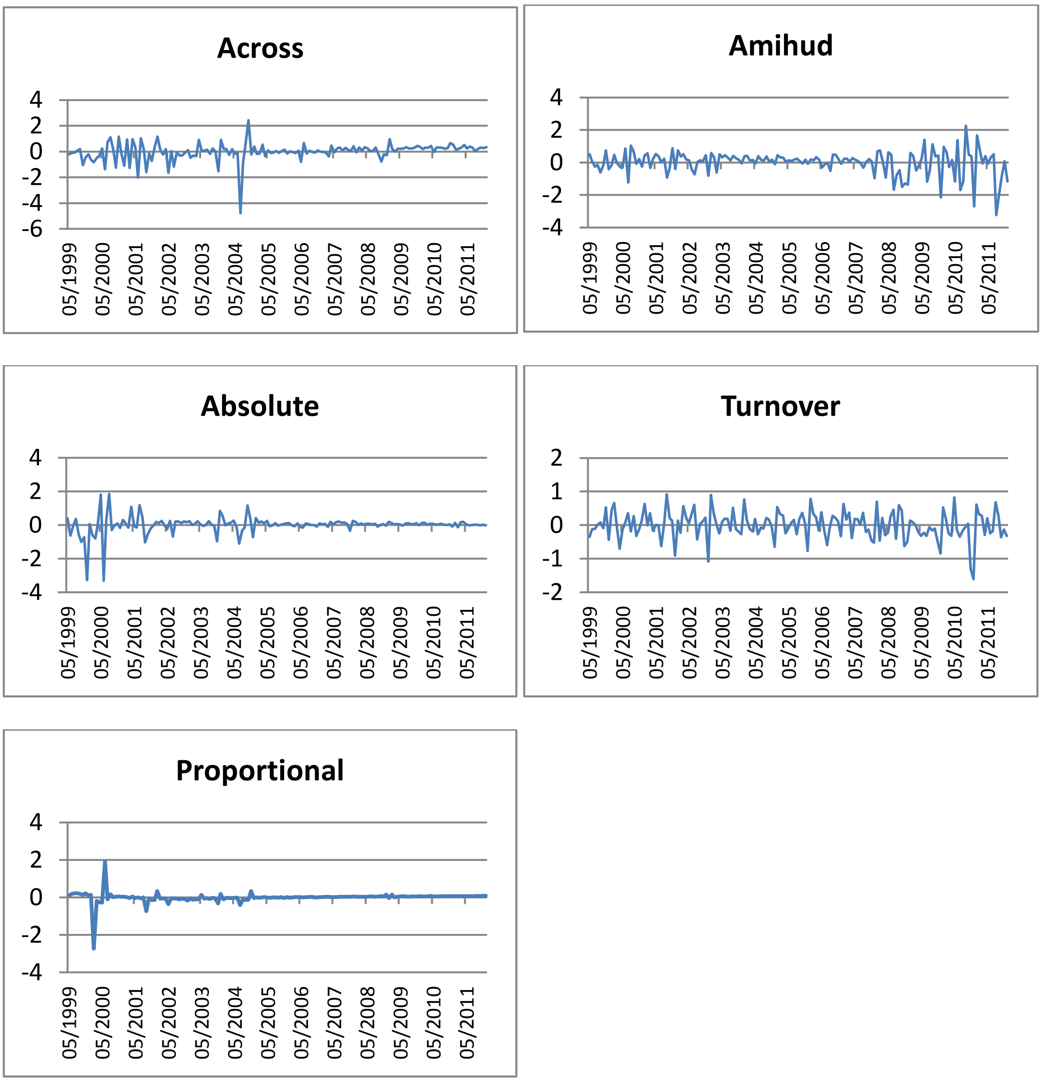


Fig 4.3: Time series of liquidity shocks

The first common factor is extracted separately for different measures of liquidity measures of liquidity using the PCA method. Additionally, we extract across-measure common factors for all the liquidity measures jointly. We fit the AR(2) model for each first principal common factor then plotted the residuals as the factor shocks. The liquidity proxies used are: Amihud (2002), defined as the monthly average of daily absolute value of return divided by pound volume and it is rescaled by market capitalization; Absolute bid-ask spread, measured as the difference between Ask and Bid price; Proportional bid-ask spread, measured as the absolute bid-ask spread divided by bid-ask min-point; Turnover defined as the ratio of monthly volume over shares outstanding. Before extracting common factors and regression analysis, we normalized all liquidity measures individually by its mean and standard deviation calculated up to the prior month (with at least five prior monthly observations).. The sample includes 186 companies from FTSE100 and FTSE250 between March 1999 and December 2011 (154 months). All the data is obtained from Datastream.



4.4.3 CONTEMPORANEOUS CANONICAL CORRELATIONS OF LIQUIDITY FACTORS

The most advantageous point of following K&S (2008) is extracting common factors from each liquidity variable and all liquidity measures together and testing correlations. None of the previous studies extracts common factors from all measures together.

This section analyzes several different measures of liquidity and the extent to which liquidity shocks are systematic across all measures. This section starts with estimating three canonical correlations between individual liquidity measures (within-measure), and across-measure using the first three extracted factors across each pair of variables. The study also looks into canonical correlation between returns, within measure and across measure. Table 4.3 presents results of pair-wise canonical correlation with unadjusted factors (raw data set) and table 4.4 presents results of pair-wise canonical correlation from pre-whitened (using an AR(2) model) factors.

Canonical correlations between each within-measure and across-measure are all statistically significant in table 4.3. The correlation between the Amihud-measure and Across-measure is about 25% and is the weakest one while proportional spread is highly correlated with across measure (63%). The correlation between liquidity and stock returns is consistent with the original paper's findings (US market). The Amihud measure, proportional spread and across-measure are correlated with stock returns and all of them are statistically significant at the 1% and 5% level respectively while this study shows statistically insignificant results for the Absolute spread and Turnover. The relation between within measure and across measure is statistically significant. The evidence from table 4.3 shows that within measures are contemporaneously correlated with across measure and the Amihud measure, proportional spread and across measure are contemporaneously correlated with returns.

Table 4.3: Canonical contemporaneous correlations (raw time series)

Three common factors are extracted separately for returns and different measures of liquidity using PCA method. The liquidity proxies used are: Amihud (2002), defined as the monthly average of daily absolute value of return divided by pound volume and it is rescaled by market capitalization; Absolute bid-ask spread, measured as the difference between Ask and Bid price; Proportional bid-ask spread, measured as the absolute bid-ask spread divided by bid-ask min-point; Turnover defined as the ratio of monthly volume over shares outstanding. Before extracting common factors and regression analysis, we normalized all liquidity measures individually by its mean and standard deviation calculated up to the prior month (with at least five prior monthly observations). This table reports the first canonical correlation (contemporaneous) between each two groups of common factors. The sample includes 186 companies from FTSE100 (71 firms) and FTSE250 (115 firms) between March 1999 and December 2011 (154 months). All the data is obtained from Datastream. We report canonical correlations (first row), the Wilks's lambda in second row (the null hypothesis: the given canonical correlation and all smaller ones are equal to zero in population) and p-value in parentheses.

	Return	Amihud	Absolute	Proportional	Turnover
Amihud	0.3869 0.7523 (0.000)				
Absolute	0.2256 0.9303 (0.290)	0.4377 0.7884 (0.000)			
Proportional	0.2961 0.8759 (0.019)	0.6711 0.5310 (0.000)	0.3733 0.8174 (0.000)		
Turnover	0.2247 0.9252 (0.236)	0.3355 0.8670 (0.011)	0.4089 0.7981 (0.000)	0.2097 0.9473 (0.526)	
Across-measure	0.2744 0.8983 (0.013)	0.2498 0.9278 (0.081)	0.5850 0.6555 (0.000)	0.6319 0.5993 (0.000)	0.5851 0.6561 (0.000)

Table 4.4 presents results of canonical correlations. These correlations are obtained after pre-whitening with an AR(2) process. Comparing table 4.3 (raw data) and table 4.4, (fitting AR(2)), the level of correlations between returns and liquidity measures do not change a lot but turnover becomes statistically significant while proportional spread becomes insignificant after fitting AR(2). The canonical correlations between the within-measure factors and the across-measure factors tend to be lower after the AR(2) process which is consistent with K&S (2008). Thus, the within-measures are strongly correlated with the across-

measure. The findings for the UK are consistent with K&S's (2008) findings for the US. The evidence suggests that if the across measure based on various measures of liquidity is important then it may improve the accuracy of estimating systematic liquidity shocks than estimating systematic liquidity shocks based on a single liquidity measure.

Table 4.4: Canonical contemporaneous correlations (fitted AR(2))

Three common factors are extracted separately for returns and different measures of liquidity using PCA method. The liquidity proxies used are: Amihud (2002), defined as the monthly average of daily absolute value of return divided by pound volume and it is rescaled by market capitalization; Absolute bid-ask spread, measured as the difference between Ask and Bid price; Proportional bid-ask spread, measured as the absolute bid-ask spread divided by bid-ask min-point; Turnover defined as the ratio of monthly volume over shares outstanding. Before extracting common factors and regression analysis, we normalized all liquidity measures individually by its mean and standard deviation calculated up to the prior month (with at least five prior monthly observations). This table reports the first canonical correlation (contemporaneous) between each two groups of common factors. The table uses the residuals of a second order autocorrelation model for each factor (using ma monthly expanding window). The sample includes 186 companies from FTSE100 (71 firms) and FTSE250 (115 firms) between March 1999 and December 2011 (154 months). All the data is obtained from Datastream. We report canonical correlations (first row), the Wilks's lambda (second row) and p-value in parentheses.

	Return	Amihud	Absolute	Proportional	Turnover
Amihud	0.3574 0.8043 (0.000)				
Absolute	0.1725 0.9639 (0.797)	0.5762 0.6564 (0.000)			
Proportional	0.2558 0.9291 (0.287)	0.1792 0.9405 (0.433)	0.3547 0.8183 (0.001)		
Turnover	0.3672 0.8350 (0.002)	0.2260 0.9117 (0.136)	0.1991 0.9435 (0.478)	0.1349 0.9781 (0.953)	
Across-measure	0.2792 0.8710 (0.002)	0.2407 0.9305 (0.100)	0.5187 0.7167 (0.000)	0.6107 0.6265 (0.000)	0.2358 0.9371 (0.142)

4.4.4 THE TEMPORAL RELATION BETWEEN LIQUIDITY AND ASSET RETURNS

As it has analysed in the previous section, several within-measures and the across-measure are contemporaneously correlated with each other and stock returns, thus it could expect that there is a relation between liquidity risk and returns. If this is so, then liquidity shocks may be able to predict future returns or vice-versa. So this section looks into this by performing a pair-wise canonical correlation analysis where one of the variables lags one period. The results are reported in Table 4.5 (raw common factors) and Table 4.6 (pre-whitened factors).

The first column in table 4.5 shows that one month lagged within-measures and the across-measure do not predict future returns except proportional spread. The first row shows that returns seem to predict most of the liquidity measures, the only exception being absolute spread.

Table 4.5: Canonical Lead-Lag Correlations (raw time series)

Three common factors are extracted separately for returns and different measures of liquidity using PCA method. The liquidity proxies used are: Amihud (2002), defined as the monthly average of daily absolute value of return divided by pound volume and it is rescaled by market capitalization; Absolute bid-ask spread, measured as the difference between Ask and Bid price; Proportional bid-ask spread, measured as the absolute bid-ask spread divided by bid-ask min-point; Turnover defined as the ratio of monthly volume over shares outstanding. Before extracting common factors and regression analysis, we normalized all liquidity measures individually (excluding return) by its mean and standard deviation calculated up to the prior month (with at least five prior monthly observations). This table reports the first canonical auto- and cross-correlations (one lag) between each two groups of common factors. Each column contains the canonical correlations between the common factors of the variable of that column and the lag common factors of each of the other variables (pair wise). The sample includes 186 companies from FTSE100 (71 firms) and FTSE250 (115 firms) between March 1999 and December 2011 (154 months). All the data is obtained from Datastream. We report canonical correlations (first row), the Wilks's lambda (second row) and p-value in parentheses.

t-1\t	Return	Amihud	Absolute	Proportional	Turnover	Across-measure
Return	0.2871 0.8873 (0.038)	0.2777 0.8619 (0.009)	0.1842 0.9517 (0.602)	0.3072 0.8480 (0.004)	0.3935 0.8090 (0.000)	0.2193 0.9259 (0.075)
Amihud	0.2610 0.9102 (0.123)	0.6539 0.4113 (0.000)	0.2921 0.8975 (0.066)	0.6582 0.5509 (0.000)	0.9059 0.1651 (0.000)	0.2543 0.9307 (0.098)
Absolute	0.1802 0.9559 (0.670)	0.2851 0.8914 (0.048)	0.8425 0.2366 (0.000)	0.3743 0.8098 (0.000)	0.4579 0.7495 (0.000)	0.5474 0.6683 (0.000)
Proportional	0.3007 0.9018 (0.082)	0.5263 0.7054 (0.000)	0.2844 0.9077 (0.110)	0.9182 0.0485 (0.000)	0.2424 0.9311 (0.305)	0.5033 0.7433 (0.000)
Turnover	0.1548 0.9752 (0.929)	0.2958 0.8967 (0.063)	0.4251 0.7991 (0.000)	0.3271 0.8893 (0.043)	0.9154 0.1581 (0.000)	0.5509 0.6807 (0.000)
Across-measure	0.0958 0.9881 (0.939)	0.1822 0.9641 (0.490)	0.4708 0.7739 (0.000)	0.4635 0.7773 (0.000)	0.5363 0.6979 (0.000)	0.7322 0.4626 (0.000)

In table 4.6, the lead-lag correlations between returns and liquidity measures have changed compared to the findings in table 4.5. Shocks to liquidity (absolute and proportional spread) can predict future stock returns. However, it shows weaker evidence of returns predicting liquidity measures. Noticeably, lagged returns do not predict across measure. Generally speaking, in contrast to the evidence of the previous section, after fitting AR(2) it becomes much weaker evidence of lagged liquidity shocks being able to predict returns and of lagged returns being able to predict liquidity shocks. The results are consistent with K&S (2008). The most important finding is that shocks to returns can predict future liquidity levels. However, lagged liquidity shocks do not predict future returns. This implies that the adjustment of liquidity risk in the UK market is quicker than the US market.

In other words, the UK stock market has a shorter life span of liquidity risk compared to the US market.

Table 4.6: Canonical Lead-Lag Correlations (fitted AR(2))

Three common factors are extracted separately for returns and different measures of liquidity using PCA method. The liquidity proxies used are: Amihud (2002), defined as the monthly average of daily absolute value of return divided by pound volume and it is rescaled by market capitalization; Absolute bid-ask spread, measured as the difference between Ask and Bid price; Proportional bid-ask spread, measured as the absolute bid-ask spread divided by bid-ask min-point; Turnover defined as the ratio of monthly volume over shares outstanding. Before extracting common factors and regression analysis, we normalized all liquidity measures individually (excluding return) by its mean and standard deviation calculated up to the prior month (with at least five prior monthly observations). This table reports the first canonical auto- and cross-correlations (one lag) between each two groups of common factors. Each column contains the canonical correlations between the common factors of the variable of that column and the lag common factors of each of the other variables (pair wise). The table uses the residuals of a second order autocorrelation model for each factor (using a monthly expanding window). The sample includes 186 companies from FTSE100 (71 firms) and FTSE250 (115 firms) between March 1999 and December 2011 (154 months). All the data is obtained from Datastream. We report canonical correlations (first row), the Wilks's lambda (second row) and p-value in parentheses.

t-1\t	Return	Amihud	Absolute	Proportional	Turnover	Across-measure
Return	0.2321 0.9114 (0.138)	0.3271 0.8598 (0.009)	0.2323 0.9252 (0.250)	0.2497 0.9353 (0.368)	0.3583 0.8144 (0.000)	0.1917 0.9505 (0.281)
Amihud	0.2628 0.9267 (0.266)	0.1760 0.9509 (0.598)	0.1457 0.9716 (0.897)	0.0829 0.9889 (0.996)	0.9224 0.1422 (0.000)	0.2575 0.9260 (0.080)
Absolute	0.3095 0.8991 (0.076)	0.3545 0.8509 (0.005)	0.2172 0.9386 (0.412)	0.2424 0.9300 (0.302)	0.5126 0.7330 (0.000)	0.5305 0.7120 (0.000)
Proportional	0.3442 0.8749 (0.021)	0.3032 0.9032 (0.094)	0.1528 0.9662 (0.832)	0.0903 0.9879 (0.995)	0.1773 0.9679 (0.854)	0.5056 0.7322 (0.000)
Turnover	0.2226 0.9461 (0.523)	0.1707 0.9575 (0.704)	0.1604 0.9726 (0.908)	0.8126 0.3274 (0.000)	0.1951 0.9611 (0.759)	0.1435 0.9738 (0.690)
Across-measure	0.1152 0.9825 (0.858)	0.0797 0.9915 (0.974)	0.3464 0.8609 (0.001)	0.1799 0.9521 (0.302)	0.1396 (0.9732 (0.678)	0.2476 0.9252 (0.022)

4.4.5 THE PRICING OF LIQUIDITY RISK AND LIQUIDITY CHARACTERISTICS IN THE CROSS-SECTION

This section investigates whether liquidity risk is priced in the cross section. In particular, this study asks whether the different liquidity measures are priced and if this is the case whether the four measures the study uses capture a different aspect of liquidity or the same. In order to draw inferences, liquidity shocks are decomposed into those driven by across measure liquidity shocks and within measure liquidity shocks. Estimating multiple-regression with the liquidity variables all together could possibly be ideal but it could have a potential matter in estimation because across measure liquidity is high correlated with other within measures.

4.4.5.1. CONSTRUCTING ACROSS-MEASURE AND MEASURE-SPECIFIC LIQUIDITY FACTORS

In order to investigate the relative importance of the across measure liquidity factor against the measure-specific liquidity factor in explaining the time variation of firm level liquidity, it needs to run a number of regressions at two different stages. Firstly in order to assess whether there is additional information in the individual liquidity factors, each of the individual liquidity factors (the first component) is orthogonalised. We do this by running the following regression (first stage):

$$\hat{F}^{i}_{1,t} = b^{i}_{0} + b^{i}_{1}\hat{F}_{1,t} + \hat{u}^{i}_{1,t} \tag{4.8}$$

Where $\hat{F}^{i}_{1,t}$ is the within-measure non orthogonalised systematic factor (the Amihud measure, absolute spread, proportional spread and turnover) and it is pre-whitened using AR(2). $\hat{F}_{1,t}$ presents the first common factor of the across-measure systematic factor (also pre-whitened using AR(2)) and $\hat{u}^{i}_{1,t}$ is the within measure orthogonalised systematic factor. At a second stage the model estimates each firm’s liquidity on the across measure and projected within measure. The regression follows (second stage):

$$\hat{F}^{i}_{1,t} = b^{i}_{0} + b^{i}_{1}\hat{A}_{1,t} + b^{i}_{2}W^{i}_{1,t} + \hat{u}^{i}_{1,t} \tag{4.9}$$

Where $\hat{F}^{i}_{1,t}$ is each firm's liquidity for liquidity proxy i, $\hat{A}_{1,t}$ is the across-measure and $W^{i}_{1,t}$ is the orthogonalized within measure from the previous regression. Superscript i represents the four liquidity proxies such as the Amihud measure, absolute spread, proportional spread, and turnover.

The importance of across measure and within measures in cross sectional analysis is shown in Table 4.7. It shows that the percentage of firms in the sample that exhibit significant coefficients at the 1% and 5% level. Also table 4.7 shows joint significance (F-statistic), average R^2, and adjusted R^2. At the 1 % significant level, the percentage of significant coefficient for across measure is lower than within measure for the Amihud measure, absolute spread and turnover except proportional spread. At the 5% level, across measure becomes significant more often than within measure for absolute spread and proportional spread while the Amihud measure and turnover show that within measure is significant more often than the across measure.

Table 4.7: Percent of firms with significant exposure to across measure and within measure factors

This table reports distribution statistics of time-series regressions. Within-measure common factors are extracted separately for different measures of liquidity using the PCA method. In addition, across-measure factors are extracted for all the liquidity measures jointly. The, for each liquidity measure of each stock, a time-series regression for the variable on the across-measure common factor (the first principal component) and the within-measure common factor (the first principal component) of the particular liquidity measure is executed (the within-measure common factor is first projected on the across-measure common factor to orthogonalize). The liquidity proxies used are: Amihud (2002), defined as the monthly average of daily absolute value of return divided by pound volume and it is rescaled by market capitalization; Absolute bid-ask spread, measured as the difference between Ask and Bid price; Proportional bid-ask spread, measured as the absolute bid-ask spread divided by bid-ask min-point; Turnover defined as the ratio of monthly volume over shares outstanding. Before extracting common factors and regression analysis, we normalized all liquidity measures individually (excluding return) by its mean and standard deviation calculated up to the prior month (with at least five prior monthly observations). The table reports the percentage of firms in the sample that exhibit significant coefficients at the 1% and 5% statistical significance levels, as well as the joint significance (F-statistics). The average R^2 and the average adjusted R^2 of these regressions are also reported below. The sample includes 186 companies from FTSE100 and FTSE250 between March 1999 and December 2011 (154 months). All the data is obtained from Datastream.

Variable	Statistical sig level (%)	Intercept	Across Measure	Within Measure	Joint Sig.	Average R^2	Average Adj. R^2
Amihud	1 5	69.9 72.6	0.54 09.7	52.1 60.2	46.2 58.1	8.2	6.9
Absolute	1 5	84.9 91.4	25.3 46.2	32.8 40.9	48.9 54.3	9.1	7.9
Proportional	1 5	77.4 81.7	12.9 62.9	04.8 11.3	18.8 25.8	4.8	3.5
Turnover	1 5	47.8 55.9	18.3 36.6	30.6 53.8	41.9 58.6	5.8	4.5

4.4.6. LIQUIDITY RISK, LIQUIDITY CHARACTERISTICS AND AVERAGE RETURNS

This section estimates and analyses the systematic liquidity risk of assets in a five-factor model that includes the across-measure liquidity factor in addition to the Fama-French three factor model and momentum. First of all, to estimate factor betas, the study estimates returns for each stock on the across-measure liquidity factor, market portfolio, HML, SMB, and momentum[26]. The first stage multiple time series regression is given below:

[26] Jegadeesh and Titman (1993) document significant abnormal returns from an intermediate-term momentum strategy. Carhart (1997) adds the momentum factor in the Fama-French three factor model to evaluate fund performance. The momentum factor represents the difference in returns between the top and bottom third of all ordinaries stocks. This study obtains the four factors from the University of Exeter’s web site: http://xfi.exeter.ac.uk/researchandpublications/portfoliosandfactors/disclaimer.php

$$R_{i,t} = \beta_{0,i} + \beta_i' f_t + \varepsilon_{i,t} \tag{4.10}$$

Where f_t is a vector of factors. The regression obtains a coefficient of the across measure which used to assign stock to portfolios. Namely, every month stocks are ranked based on their beta relative to the across measure using the past 36 months of data[27]. It creates 12 portfolios and 15 assets are allocated to each portfolio. Returns for each portfolio are calculated and then estimates excess returns by deducting risk free rate for each portfolio and run a second stage regression. The purpose of this second stage regression is to estimate the beta of the liquidity risk portfolio (i).

Table 4.8 shows the average portfolio return in excess of the one-month risk-free return, Jensen alpha relative to a four-factor model where the factors are MKT, HML, SMB, and UMD and the post ranking liquidity betas excess returns. FF4 alpha and post-ranking beta tends to increase from the lowest liquidity beta portfolio to the highest liquidity beta portfolio. Coefficients of excess returns are positive and statistically insignificant. It shows negative and positive coefficients of FF4 alpha which are mostly insignificant. Across-measure betas, however, are mostly positive except P1. The across-measure betas are statistically insignificant except the large size of portfolios (P10 and P12). Figure 4.4 shows a plot of the four-factor alpha against the portfolio systematic liquidity beta of the 12 portfolios. If liquidity risk is priced independently of the four factors in the asset pricing model (MKT, HML, SMB, and UMD) then it can expect a statistically significant positive relationship between the alpha and the liquidity beta. The result shows in Figure 4.4 that there is a significant relation between the alpha

[27] It requires 24 months of data out of the past 36 months in order to include an asset.

and the liquidity beta in the UK stock market which is consistent with the finding from the US market by Korajczyk and Sadka (2008).

Table 4.8: Performance of across-measure-liquidity-loading-sorted portfolios

Across-measure common factors are extracted jointly for different measure of liquidity measures using PCA method. 12 portfolios are sorted each month by the across-measure liquidity loading estimated using the past 36 months (the loading is computed while controlling for Fama-French four factors). The time-series mean return (excess of risk-free rate) and risk-adjusted returns (using Fama-French four factors) of each portfolio are presented below. Portfolio returns are quoted in percent. The liquidity proxies used are: Amihud (2002), defined as the monthly average of daily absolute value of return divided by pound volume and it is rescaled by market capitalization; Absolute bid-ask spread, measured as the difference between Ask and Bid price; Proportional bid-ask spread, measured as the absolute bid-ask spread divided by bid-ask min-point; Turnover defined as the ratio of monthly volume over shares outstanding. Before extracting common factors and regression analysis, we normalized all liquidity measures individually (excluding return) by its mean and standard deviation calculated up to the prior month (with at least five prior monthly observations). All variables are obtained from the datastream. The sample period is between 01.2002 and 12.2010. We use 186 companies from FTSE100 (71 firms) and FTSE250 (115 firms). Newey-West t-statistics are in the bracket. * presents statistically significant coefficient at 10%.

FTSE100 and FTSE250 (01.2002 ~ 12.2010)			
Portfolio ranking	Excess return	FF4 alpha	FF4+All loadings
P1 (Low)	0.0024 (0.2798)	0.00039 (0.1428)	-0.00159 (-0.8165)
P2	0.0012 (0.1503)	-0.00155 (-0.5628)	0.00135 (0.6404)
P3	0.0055 (0.8238)	0.00328 (1.3090)	0.00168 (0.7153)
P4	0.0040 (0.4531)	0.00158 (0.6358)	0.00065 (0.3778)
P5	0.0013 (0.1683)	-0.00106 (-0.4164)	0.00391 (1.0844)
P6	0.0019 (0.3422)	-0.00124 (-0.5082)	0.00258 (0.7674))
P7	0.0031 (0.5271)	0.00017 (0.0582)	0.00345 (0.9536)
P8	0.0036 (0.6406)	0.00080 (0.3334)	0.00112 (0.6786)
P9	0.0054 (0.8518)	0.00236 (1.0903)	0.00412 (1.5581)
P10	0.0032 (0.4976)	-0.00038 (-0.1305)	0.00536 (2.4133)*
P11	0.0071 (0.9695)	0.00386 (1.3701)	0.00428 (1.4511)
P12 (High)	0.0099 (1.0149)	0.00761 (1.6296)	0.01115 (3.6609)*
12-1 (high-low)	0.00744 (1.5904)	0.00723 (1.7974)	0.01274 (5.7922)*
12-2 (high-low)	0.0087 (1.8675)*	0.00917 (2.5482)*	0.00756 (2.7716)*

Figure 4.4. Risk-adjusted returns and liquidity loadings

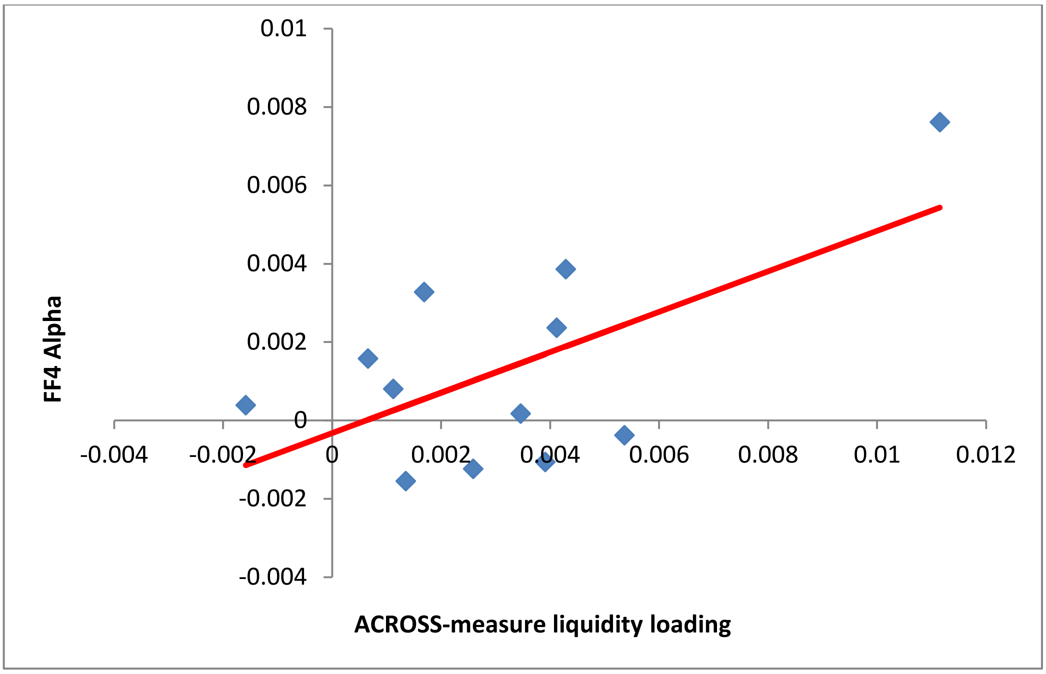


Figure 4.4. Across-measure common factors are extracted jointly for different measure of liquidity measures using the PCA model. AR(2) model is fitted to factor shocks then residuals are used to allocate 12 portfolios. These portfolios are sorted each month by the across-measure liquidity beta estimated using the past 36 months (at least 24 months are required out of 36 months to include). The risk-adjusted returns of each portfolio p, alpha, are calculated using Fama-French four factors. In addition, the loading of each portfolio on the across-measure liquidity factor is calculated using a time series regression on returns including the Fama-French four factors. The line plots the fitted regression model. The number in bracket is p-value.

α_p= -0.00032 + 0.5158 $\beta_{LIQ,p}$+ ε_p

[0.7318] [0.0321]

4.4.7 CROSS-SECTIONAL REGRESSIONS

Since a significant relation exists between FF4 alpha and across measure liquidity as shown in the previous section, it tests explicitly for the pricing of liquidity in the cross section. The asset pricing models used are the following:

$$R_{i,t} = \gamma_{0,t} + \gamma_t' \beta_{i,t} + \delta_t' Z_{i,t-1} + \varepsilon_{i,t} \tag{4.11}$$

Where $R_{i,t}$ denotes the return of portfolio i (excess of risk-free rate), β_i is the vector of factor loadings of asset i relative to several different risk factors such as SMB, HML, MKT, UMD, the across-measure and within-measure liquidity factors. γ is a vector of factor premia, Z_i are characteristics (in month t-1), such as the raw liquidity measures, size, and the book-to-market equity ratio, and δ is a vector of characteristic premia. The test uses the beta relative to the across-measure liquidity which is estimated in the previous section. Also, it reports Newey-west t-statistics for hypothesis testing. First, the CAPM is examined using MKT including unstandardized level of the liquidity measure as a characteristic premium. Second, the model is estimated with three factor premiums such as MKT, Across-measure, and Within-measure (orthogonalized factor to across-measure) but exclude the illiquidity characteristic. The third model specification includes MKT, the liquidity factors, and the illiquidity characteristic. Then, the test is repeated with addition of the SMB, HML, and UMD factors in the model. Finally, it adds two additional characteristics, the logarithm of the stocks' market capitalization (size) and the book-to-market equity ratio.

The results of the cross-sectional regressions are presented in table 4.9, model 1 (M1) shows that the coefficient for MKT is positive and significant for all measures. The premium for illiquidity as a characteristic is significant for

Amihud and Turnover while Absolute and Proportional spread are insignificant. Model 2 (M2) shows that the coefficients for MKT remain significant even after including Across-measure and within-measure. The coefficients for Across-measure are statistically significant for absolute spread (positive) and turnover (negative). The coefficients for projected within-measures are all insignificant. As illiquidity is included in the model (see Model 3), the result of regression is not changed. MKT remains significant for all measures, the Across-measure is significant for absolute and turnover and the coefficients for Amihud and turnover as characteristics are significant. Overall, the CAPM beta is positive and statistically significant and remains unchanged when additional variables are included such as Across-measure, within-measure and illiquidity characteristics. Also Across-measure is consistently significant for absolute and turnover over models 2 & 3. The Amihud and Turnover as characteristics are statistically significant in models 1 & 3. Now, the Fama-French four factor model with characteristic variables is examined. The factors are MKT, SMB, HML, UMD, and the characteristic variables are illiquidity measure, size and book-to-market ratio. Model 4, 5, and 6 in table 4.9 show that MKT and SMB factor premium are statistically significant for all measures and the coefficient of MKT and SMB are all positive while HML and UMD are negative. More importantly, the coefficient of across-measure becomes insignificant when adding the Fama-French four factors.

To compare with K&S (2008), the results show that the premia on betas relative to MKT, SMB, and HML (HML becomes insignificant in models 5 & 6 when across measure, within measure and characteristics are added) are significant while K&S(2008) report that Fama-French four factors are insignificant. This implies that the average small share is riskier than the average large share. Also the share with a high balance sheet value per share relative to the market value of each share is more risky than a share with a low book value compared with the share prices in the UK market. The overall across-measure liquidity factor in the study presents a mixed result which is varying with model specification (the across-measure becomes insignificant with additional variables such as the Fama-French factors and momentum, see models 5 & 6) while the US market (K&S, 2008) earns consistently a statistically significant premium regardless of the specification. Results obtained for illiquidity premia (Amihud and turnover) as characteristics are consistent with K&S (2008) who report statistically significant premia for the Amihud measure and turnover however this pattern breaks with the Fama-French factors and across and within measures. In the last model (model 6), however, turnover is the only characteristic premium which remains significant. The premium for size characteristic is insignificant while book-to-market equity characteristic is significant for all measures.

Liquidity risk for the UK market is weakly priced compared to the US evidence (S&K, 2008). More specifically, coefficients of non-risk illiquidity characteristics and systematic liquidity risk (Across-measure) are varying with model specification. The stock portfolios based on the level of liquidity in the UK market show that the high book value relative to the market value is more risky than the low book value compared with the share price. This mixed result could be due to the smaller sample size and fewer liquidity measures used (using 4 measures and S&K uses 8 measures) to extract the systematic risk factor (Across-measure).

4.5. CONCLUSION

Since liquidity is not a simple concept to explore and not directly observable, a number of liquidity measures have been proposed. Even though, various liquidity proxies are widely used in asset pricing studies, there is no such thing as a superior proxy that is able to capture all facets of liquidity. Following K&S (2008), the study estimate an across-measure which is obtained by extracting common factors across a number of different measures of liquidity in order to combine as many different dimensions of liquidity as possible for the UK market.

Results of this study are consistent with evidence from the US market (K&S, 2008). It confirms that there is strong commonality across assets for each individual measure of liquidity (consistent with Galariotis & Giouvris, (2007 & 2009) and Gregoriou, Ioannidis, and Zhu (2011)) and that these common factors (within measure) are correlated across different liquidity measures. The relation between within measure and across-measure is statistically significant and these measures are contemporaneously correlated with returns. Also this study shows that changes in liquidity measures are correlated with each other and with the across-measure. Shocks to returns can predict future liquidity levels. However, lagged liquidity shocks do not predict future returns. Additionally, the UK stock market shows relatively weaker persistence of liquidity compared to the US market. This implies that the adjustment of liquidity risk in the UK market is faster than the US market. In other words, the UK stock market has a shorter life span of liquidity risk compared to the US market.

Finally it examines if liquidity is priced using different specifications (CAPM benchmark and Fama-French four factor benchmark) with across-measure liquidity factor as well as within-measures which are orthogonalized to the across-measure. It shows an weaker evidence regarding the pricing of liquidity. For instance, the CAPM beta is statistically significant in all models tested and the across-measure is significant in models 2 & 3. Also the Amihud and turnover illiquidity variables as characteristics are always significant. After controlling for the Fama-French four factors, however, the coefficient of across-measure becomes statistically insignificant. Only turnover and book-to-market ratio are priced after controlling for the Fama-French factors and across and within measures. The stock portfolios based on the level of liquidity in the UK market show that the high book value relative to the market value is more risky than the low book value compared with the share price. This weaker evidence regarding the pricing of liquidity for the UK market could stem from weaker persistence of liquidity compared to the US market, smaller sample size and fewer proxies used (we use 4 liquidity proxies while K&S(2008) use 8 proxies) to estimate the across-measure.

Table 4.9: Pricing liquidity in the cross-section

We extracted within-measure factors separately for different measures of liquidity using the PCA method and across measure common factors are extracted for all the liquidity measures jointly. Factor loadings are calculated using time-series regressions of returns to 12 portfolios on the Fama-French four factors, the across-measure common factor (the first principal component) and the within-measure common factor (the first principal component) of the particular liquidity (the within-measure common factor is first projected on the across-measure common factor to orthogonalize the two factors). 12 portfolios are sorted each month by the across-measure liquidity loading estimated using the past 36 months (the loading is computed while controlling for Fama-French four factors). The results of Fama-Macbeth regressions of individual stock returns on the factor loadings are reported below (Newey-West adjusted t-statistics in parentheses). The liquidity measure (estimated the previous month) of each stock (Illiquidity) is also added to the cross-sectional regressions, as well as the natural logarithm of market capitalization (in millions of dollars) (size) and book-to-marketratio (as of the previous month) (B/M). The liquidity proxies used are: Amihud (2002), defined as the monthly average of daily absolute value of return divided by pound volume and it is rescaled by market capitalization; Absolute bid-ask spread, measured as the difference between Ask and Bid price; Proportional bid-ask spread, measured as the absolute bid-ask spread divided by bid-ask min-point; Turnover defined as the ratio of monthly volume over shares outstanding. Before extracting common factors and regression analysis, we normalized all liquidity measures individually (excluding return) by its mean and standard deviation calculated up to the prior month (with at least five prior monthly observations). While added to the cross-sectional regressions, the liquidity measures are not normalized; the Amihud measure are multiplies by 10^5, and proportional spread and turnover are multiplied by 100. The sample period is between 01.2002 and 12.2010. We use 186 companies from FTSE100 (71 firms) and FTSE250 (115 firms). * presents statistically significant coefficient at 10%. t-statistics and p-value are in bracket respectively.

Measure		Factor premium						Characteristic premium		
		MKT	SMB	HML	UMD	Across-measure	Within-measure	Illiquid	Size	B/M
M1	Amihud	0.0546 (13.729)* (0.0000)						0.0015 (3.5606)* (0.0085)		
	Absolute	0.0549 (14.121)* (0.0000)						-0.00035 (-1.6755) (0.1185)		
	Proportional	0.0553 (13.561)* (0.0000)						-0.00046 (-1.3509) (0.2189)		
	Turnover	0.0552 (14.008)* (0.0000)						-0.0069 (-8.9785)* (0.0000)		
M2	Amihud	0.0526 (12.4609)* (0.0000)				0.00058 (1.6775) (0.1369)	-0.000081 (-0.3391) (0.6617)			
	Absolute	0.0526 (12.9039)* (0.0000)				0.00059 (1.7156)* (0.0994)	-0.000047 (-0.0521) (0.4952)			
	Proportional	0.0525 (13.7744)* (0.0000)				0.00507 (1.5626) (0.1488)	0.00226 (1.7356) (0.1518)			
	Turnover	0.0518 (12.3681)* (0.0000)				0.00593 (1.9919)* (0.0669)	-0.00031 (-0.9044) (0.3759)			

M3	Amihud	0.0523 (12.7227)* (0.0000)				0.00058 (1.3586) (0.2078)	0.00016 (0.8648) (0.4012)	0.00147 (4.2294)* (0.0010)		
	Absolute	0.0535 (13.2722)* (0.0000)				0.00038 (1.9181)* (0.0774)	0.00014 (0.3843) (0.4954)	-0.00028 (-1.7549) (0.1179)		
	Proportional	0.0531 (13.5759)* (0.0000)				0.00043 (1.7521) (0.1092)	0.00197 (1.5242) (0.2197)	-0.00029 (-1.3296) (0.2383)		
	Turnover	0.0530 (12.9440)* (0.0000)				0.00036 (2.6317)* (0.0266)	-0.00026 (-0.8411) (0.3815)	-0.0065 (-7.9973)* (0.0000)		
M4	Amihud	0.0517 (11.8889)* (0.0000)	0.0243 (5.0716)* (0.0011)	-0.0097 (-2.4199) (0.1189)	-0.0007 (-0.0233) (0.6793)			0.00134 (4.4196)* (0.0065)		
	Absolute	0.0510 (15.1896)* (0.0000)	0.0238 (5.6794)* (0.0005)	-0.0080 (-2.4384)* (0.0673)	-0.0024 (-0.4207) (0.6488)			-0.00035 (-1.7657) (0.1111)		
	Proportional	0.0512 (13.7163)* (0.0000)	0.0242 (5.4179)* (0.0003)	-0.0088 (-2.7616)* (0.0478)	-0.00003 -0.5499 (0.6261)			-0.00049 (-1.5228) (0.1571)		
	Turnover	0.0510 (20.0027)* (0.0000)	0.0185 (4.4018)* (0.0036)	-0.0107 (3.1868)* (0.0110)	-0.00006 (-1.7149) (0.1719)			-0.00655 (-8.984)* (0.0000)		
M5	Amihud	0.0489 (15.3688)* (0.0000)	0.0244 (5.2715)* (0.0037)	-0.0068 (-2.0269)* (0.1032)	-0.0024 (-0.4787) (0.6444)	0.00047 (1.2211) (0.2566)	-0.00044 (-1.6469) (0.1326)			
	Absolute	0.0485 (14.8645)* (0.0000)	0.0217 (4.4782)* (0.0010)	-0.0061 (-1.6683)* (0.1957)	-0.0034 (-0.6601) (0.5856)	0.00049 (1.4357) (0.1972)	-0.00019 (-0.3826) (0.4679)			
	Proportional	0.0485 (15.4445)* (0.0000)	0.0212 (4.5548)* (0.0037)	-0.0061 (-1.6077) (0.1787)	-0.0038 (-0.7778) (0.5151)	0.00043 (1.0477) (0.3253)	0.00199 (1.5668) (0.2249)			
	Turnover	0.0461 (13.2827)* (0.0000)	2.25 (4.9999)* (0.0013)	-0.0062 (-1.7051) (0.1705)	-0.0044 (-0.8852) (0.4456)	0.00051 (1.5758) (0.1513)	-0.00075 (-2.2131)* (0.0718)			

M6	Amihud	0.0467 (13.3850)* (0.0000)	0.0215 (6.2541)* (0.0003)	-0.0054 (-1.6725) (0.2089)	0.0043 (1.5554) (0.2367)	0.00025 (1.6950) (0.1620)	-0.000704 (0.0171) (0.5738)	-0.00049 (-1.2183) (0.3408)	0.0026 (1.5798) (0.2201)	0.00001 (4.3128)* (0.0318)
	Absolute	0.0479 (14.7539)* (0.0000)	0.0216 (6.3906)* (0.0000)	-0.0058 (-1.7603) (0.1871)	0.0037 (1.3124) (0.2519)	0.00028 (1.7752) (0.1322)	0.00015 (0.3179) (0.4383)	-0.000068 (0.7423) (0.4865)	0.0016 (1.0899) (0.4126)	0.0000084 (4.1336)* (0.0048)
	Proportional	0.0479 (15.5079)* (0.0000)	0.0214 (6.1088)* (0.0004)	-0.0055 (-1.6233) (0.1922)	0.0036 (1.2476) (0.2624)	0.00027 (1.5798) (0.1715)	0.000072 (0.7817) (0.4595)	-0.00015 (-1.4455) (0.2997)	0.0013 (0.8773) (0.4879)	0.0000008 (4.3993)* (0.0047)
	Turnover	0.0474 (16.9698)* (0.0000)	0.0189 (5.3006)* (0.0002)	-0.0074 (-2.5066)* (0.0678)	-0.0014 (-0.1810) (0.5223)	0.00025 (2.1319) (0.1347)	-0.00038 (-1.5362) (0.2699)	-0.00043 (-5.0675)* (0.0039)	0.00092 (0.9249) (0.4132)	0.00000054 (5.2386)* (0.0065)

CHAPTER 5: THE STOCK MARKET LIQUIDITY AND THE BUSINESS CYCLE: EMPIRICAL STUDY FOR THE EMERGING MARKETS

5.1 INTRODUCTION

Since the subprime crisis in 2007, market microstructure literature has focused on the importance of liquidity level because liquidity is a crucial feature of stock market development. Brown et al. (2008) argue that the pattern of liquidity risk is different between markets and the main determinants of value premium (difference between the average return of a value portfolio and that of a growth portfolio) are different for each market. Moreover, Karolyi, Lee, and Dijk (2012) use 40 countries to investigate the main determinant of commonality in liquidity. Their finding shows that demand side factors (trading behaviour of investors, investor sentiment, and incentives to trade individual securities) are the main determinants of commonality in liquidity in many countries while supply side factor (funding liquidity) is the main driver of commonality in liquidity in the US during the recent crisis. They emphasize that common buying or selling pressures due to the correlated trading across stock (or due to growing institutional ownership) contribute more in explaining the level and dynamics of commonality in liquidity for many other countries. This is one area of market microstructure literature which has received a lot of attention lately while other areas such as market microstructure and the macro economy have been somehow neglected. This chapter looks into this area.

An early study by Levine and Zervos (1998) looks into the empirical relationship between stock market indicators, banking development and economic growth over 47 countries from 1976 through 1993. The main finding suggests that stock market liquidity (Turnover and Value trade which is calculated by dividing trading volume by GDP) and banking development are both positively and robustly correlated with contemporaneous and future rate of economic growth. A study by Naes, Skjeltorp, and Odegaard (2011) (hereafter NSO), shows that market liquidity can predict economic growth in the US market. They use the Amihud, LOT, and ROLL measure as liquidity proxies from 1947 to 2008 and macroeconomic variables such as GDP, unemployment, consumption and investment. The paper shows that market illiquidity is able to predict macroeconomic variables even after controlling for financial variables such as term spread, credit spread, volatility, and excess market return. Also it shows that the illiquidity of smaller firms is more informative about future economic conditions.

However, Galariotis & Giouvris (2013) (hereafter G&G) argue that the relationship between illiquidity proxies and macroeconomic variables given by NSO (2011) is not a global phenomenon but it is country specific because markets do not behave in a uniform manner. In their investigation, the Amihud and ROLL measures are used for capturing the effect of illiquidity on economic indicators between 1995 and 2010 and their empirical model also includes global liquidity (global liquidity is captured by creating a new variable which incorporates liquidity for all countries in the sample plus USA liquidity). Their findings indicate that some liquidity variables are better at predicting the future economy but those variables are not the same for all countries and global liquidity outperforms national liquidity. Also small firms' liquidity does not dominate large firms' liquidity. Given the findings in NSO (2011) and G&G (2013) which do not preclude each other, the study believes that further investigation is necessary. Previous papers dealt mainly with G8 countries. In order to draw robust empirical evidence, I looked into a mix of developing & developed economies within Asia-Pacific Economic Cooperation (APEC) organisation such as Australia, Hong Kong, Korea, Philippines, Malaysia and Singapore [28]. Choosing these countries to investigate is important because there is no specificity with G8 countries such as the degree of market development, size of economy, geographical particularity and the origin of main contribution to the economic growth. Moreover, these countries are under researched and different in terms of the economic model they have adopted for their development. For instance, Singapore and Hong Kong are well known as the leading financial centre while other countries are known as manufacturer such as Korea, Malaysia, and Philippines. This implies that each country has a different set of regulations for the sector which contributes mostly to the economic growth.

Figure 5.1, presents the behaviour of market illiquidity around economic recessions for all six countries. The Amihud's (2002) ratio (hereafter AM) and Roll's effective spread (hereafter RO) are used for capturing illiquidity and recessions are identified as periods where there is negative GDP growth for two consecutive quarters. Looking at the behaviour of the two time series together (illiquidity and GDP growth) could provide a clear picture at the pre-development

[28] The choice of countries is not arbitrary. We tried to include more countries in our sample. However, data availability considerably reduced our ability to undertake a more thorough study.

stage. Generally, it shows a rather mixed behaviour between illiquidity and recessions compared to NSO who find that an increase in illiquidity consistently predicts recessions in the US. Australia and Hong Kong provide mixed results based on national AM (NAM) and national RO (NRO)[29]. For Korea and Malaysia, it obtains findings which support NSO based on NAM while NRO shows a mixed result. Also the finding for Philippines and Singapore support NSO (2011) partially based on both NAM and NRO. Overall, national illiquidity (both NAM and NRO) exhibits a mixed behaviour with both increases and decreases before an economic recession except Korea and Malaysia which exhibit an increasing NAM before a recession.

The above results are supporting the findings of G&G (2013) confirming that there is no specificity arising from the degree of market development, size of economy and geographical particularity. For instance, while the two previous studies concentrated on the biggest markets, it investigates developing and developed markets within Asia-Pacific Economic Cooperation (APEC) organisation.

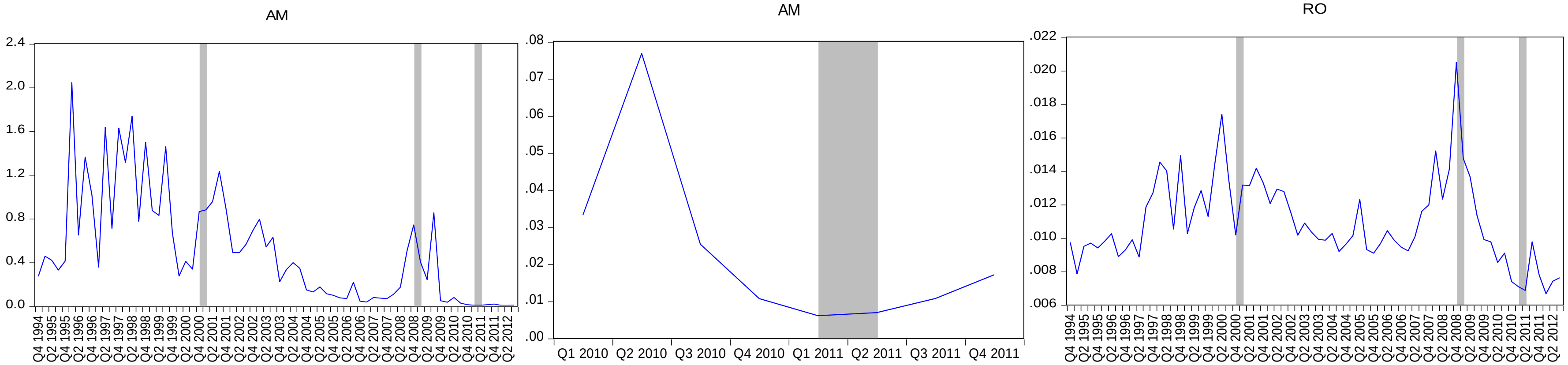
[29] More specifically, we identify three recessions for Australia and national AM (NAM) increases twice and decreases once before the recession while national RO (NRO) decreases twice and increases once. For Hong Kong, national AM (NAM) increases twice only out of seven recessions and national RO (NRO) increases four times out of seven.

Figure 5.1

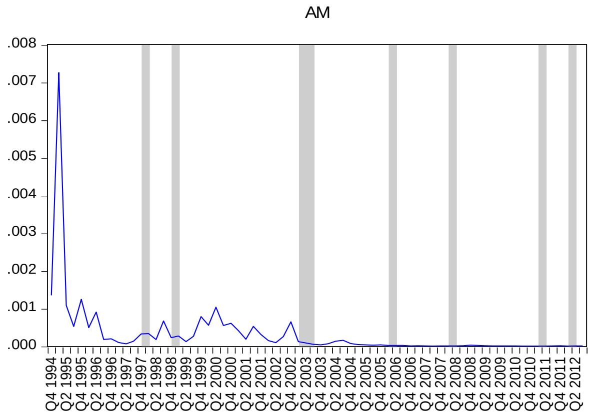
Liquidity and Business Cycle

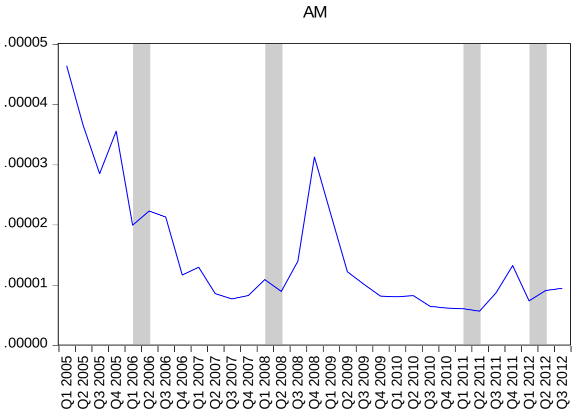
The figure shows time series plots of the Amihud ratio (AM) and the effective ROLL estimator (RO) for all countries in our sample. The recession period is showing by vertical grey lines. A recession period is identified as a period for which there is negative GDP growth.

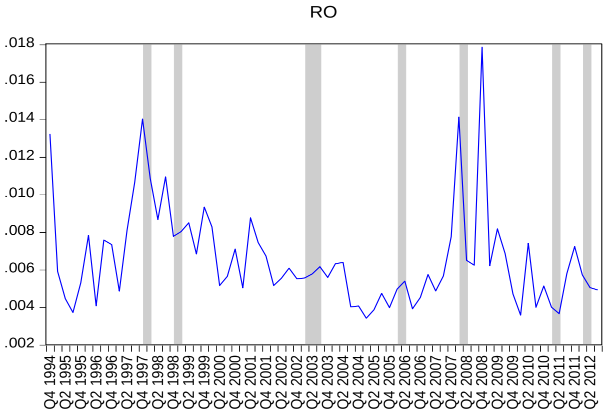
Australia



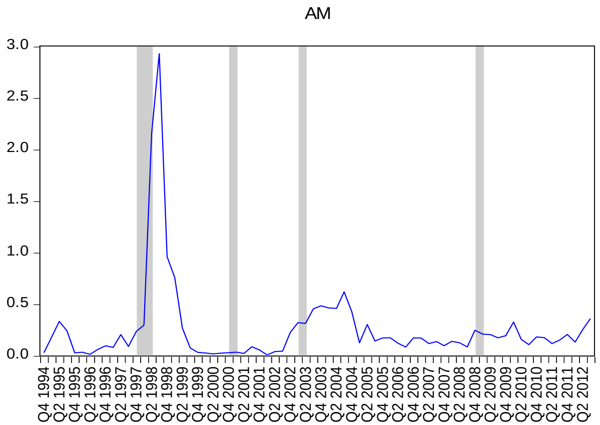
Hong Kong

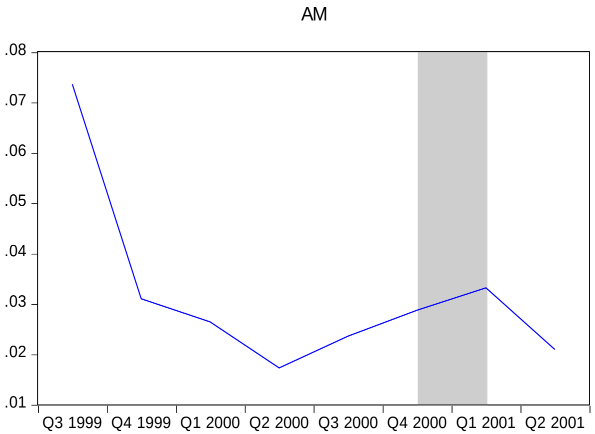


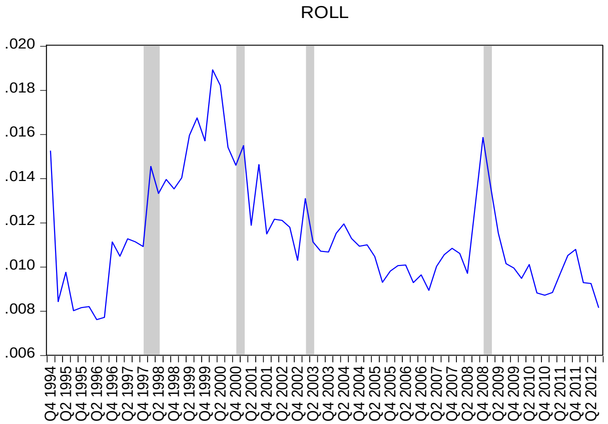




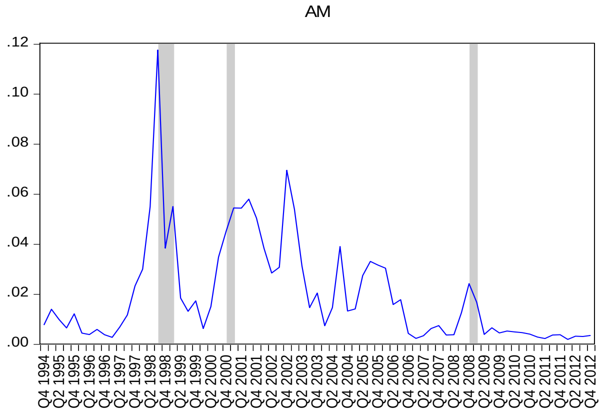
Korea

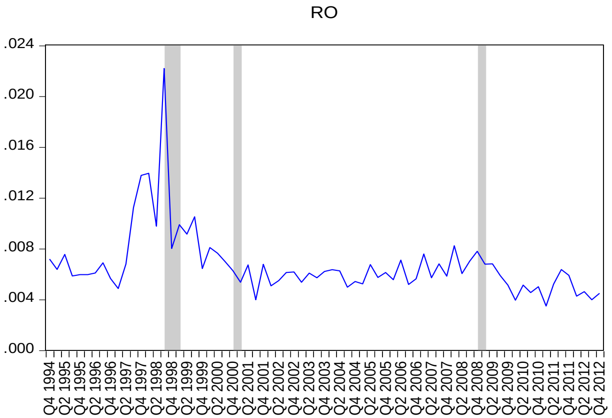




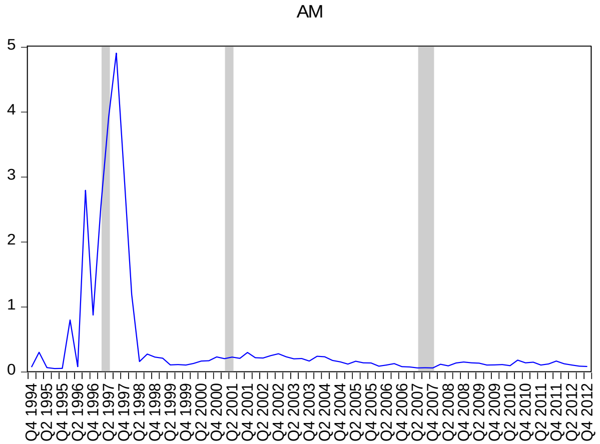


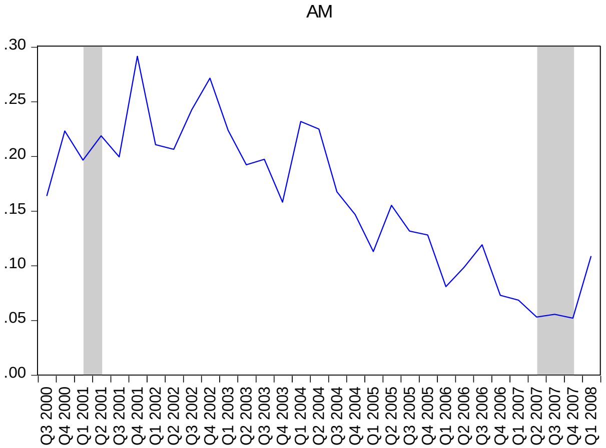
Malaysia

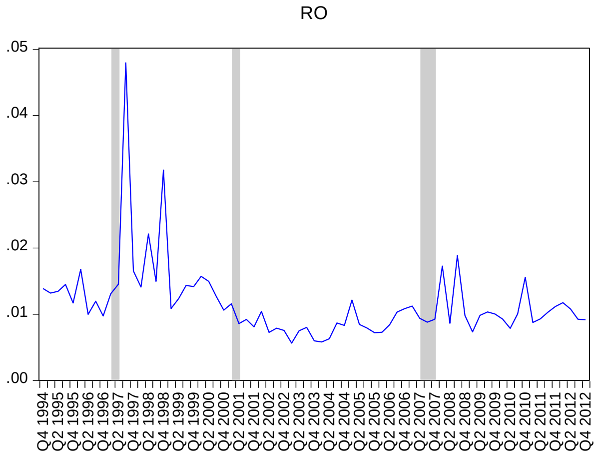




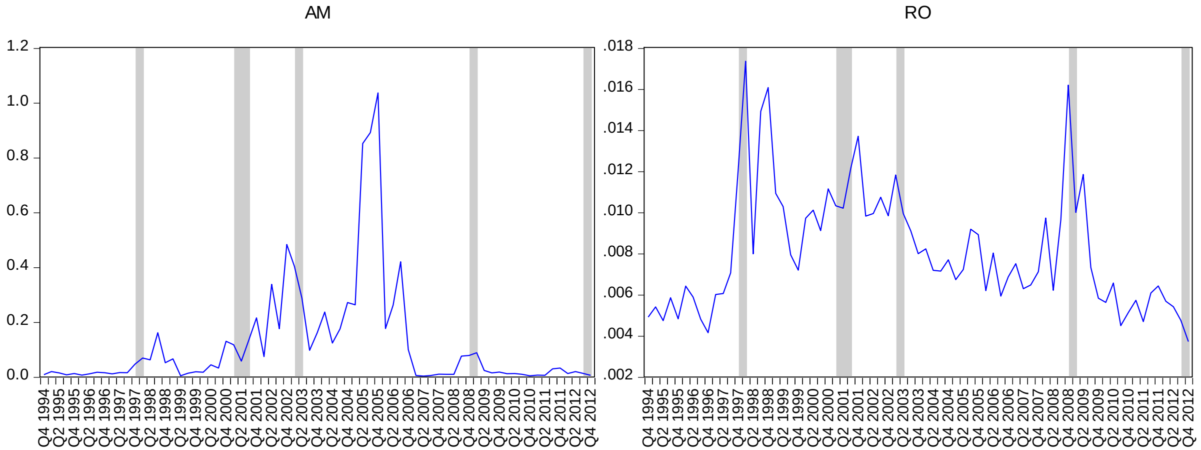
Philippines







Singapore



This is an empirical study relevant to market microstructure literature. Moreover, it expands the market microstructure literature to the field of macroeconomic forecasting by looking at the effect of liquidity on macroeconomic indicators for a mix of developed and developing economies not investigated before. Additionally, the study looks at the behaviour of the relationship between liquidity and macroeconomic indicators in developed and developing markets separately. The rest of the paper is structured as follows. First, Section 5.2 looks at the various liquidity measures and macroeconomic variables analytically. Section 5.3 looks into the relationship of illiquidity and economic growth by performing within-sample and out-of sample tests. Section 5.4 demonstrates the effect of small and large firms' liquidity on macro indicators. Finally, section 5.5 concludes.

5.2. LIQUIDITY MEASURES AND ECONOMIC INDICATORS

5.2.1 LIQUIDITY PROXIES

As this study follows G&G (2013), the investigation is fulfilled with the following liquidity proxies; the Amihud ratio (AM) and the Roll's implicit spread estimator (RO). These proxies represent illiquidity which implies that an increase in AM or RO is equivalent to a decrease of liquidity. Most importantly these proxies are easy to create over long periods of time.

This study calculates National AM (NAM) and National RO (NRO) for every stock and then average over the quarter in each country. Also it creates Global Amihud (GAM) and Global ROLL (GRO) following G&G (2013) and Brockman, Chung, and Perignon (2009). The variable includes US liquidity and Japanese liquidity which could possibly have an impact on the selected countries. The US market has been shown to have an effect on smaller markets (Brockman, Chung, and Perignon 2009) while Japan is the biggest market in East Asia. In table 5.1, panel A presents descriptive statistics of liquidity measures for all countries and panel B shows that liquidity variables (NAM and NRO) are significantly correlated with each other for Australia, Philippines, and Malaysia while insignificant correlations are obtained for Hong Kong, Korea, and Singapore.

Table 5.1

Descriptive Statistics and Correlations between Liquidity Variables

Table 5.1, Panel A shows descriptive statistics (mean and median) for liquidity measures and all 6 countries. Panel B shows correlations between liquidity variables for each country in the sample. The number in brackets is the p-value. The correlations are calculated across all stocks and time i.e. the liquidity measures are calculated for each available stock once each quarter and the correlations are pairwise correlations between these liquidity measures.

Panel A: Descriptive Statistics

	Australia		Hong Kong		Korea		Singapore		PhilippineS		Malaysia	
	mean	median	mean	median	mean	median	mean	median	mean	median	mean	median
AM	0.504	0.375	0.0003	7.8E-05	0.258	0.164	0.119	0.031	0.399	0.141	0.019	0.013
RO	0.011	0.010	0.0063	0.0057	0.011	0.010	0.008	0.007	0.011	0.010	0.007	0.006

Panel B: Correlations between Liquidity Variables

	Australia	Hong Kong	Korea	Singapore	PhilippineS	Malaysia
	RO	RO	RO	RO	RO	RO
AM	0.356 (0.002)	-0.037 (0.755)	0.128 (0.285)	0.187 (0.114)	0.550 (0.000)	0.488 (0.000)

5.2.2 MACROECONOMIC AND MARKET DATA

In order to capture economic growth, the study employs real GDP growth (GDP), unemployment growth rate for full time workers (UN), real personal consumption growth (CONS) and real private fixed investment growth (INV). Following financial variables are used as controlling factors namely volatility, excess market returns and dividend yield. Unlike G&G (2013), it does not include "term structure" because it is available for a very short period of time for Philippines, Singapore, and Malaysia[30]. Volatility (SD) is calculated as the standard deviation of daily average returns for the same stocks over each quarter. Excess market returns (EXR) are calculated as the value weighted return in excess of the risk-free rate. The model uses monthly market dividend yield (DY) and then average it over each quarter.

The sample is quarterly based. All data are from DataStream and the sample starts in Q4 1994 and ends in Q3 2012 for Australia, Hong Kong, Korea, Singapore, Malaysia and Philippines. The stating date of the sample is determined by Philippines. Although macroeconomic data goes further back in time, liquidity and other variables are not available.

5.2.3 TIME SERIES ADJUSTMENT OF SERIES AND CORRELATIONS

If non-stationarity is present, the series may increase or decrease over time which causes major problems with regressions such as biasedness of the standard errors. This means that conventional criteria used to decide whether there is a causal relationship between the variables are unreliable. In order to test for stationarity,

[30] We wish to use an econometric model which employs the same controlling factors for all countries in our sample. This will help with the interpretation of our results.

it runs two unit root tests. Firstly, it runs the Augmented Dickey-Fuller (ADF) test. Secondly, it takes the Phillips-Perron (1988) test which proposes an alternative method of controlling for serial correlation. All macroeconomic variables (GDP, UN, CONS, and INV) have been differenced to become stationary for all 6 countries. Also when any other variables (liquidity and financial variables) are non-stationary, then they are differenced. All dependent variables are orthogonalized to avoid multicollinearity, if they are correlated with each other[31].

Table 5.2 shows contemporaneous correlations between different variables for all countries in the sample. Panel A presents correlations between macroeconomic variables and liquidity (national and global) and Panel B shows correlations between macroeconomic variables and financial variables (SD, EXR, DY). The correlation between financial variables and liquidity variables is presented in panel C. The data used in table 5.2 is raw data.

Generally, liquidity variables are correlated with macroeconomic variables (Panel A). Initially, the study performs the analysis by grouping countries based on the number of significant correlations observed for each country. The first group (Australia, Korea, and Malaysia) presents significant correlations between liquidity variables and macroeconomic variables at least 13 out of 16 times or 81%. In the second group, the number of significant correlations is less than the first group. The second group includes Hong Kong (9 out of 16 or 56%), Singapore (12 out of 16 or 75%) and Philippines (11 out of 16 or 68%). When it looks at individual liquidity across all countries, global AM (GAM) scores the highest number of correlations between liquidity and macroeconomic indicators

[31] Please see the table A1 in Appendix for the detail of orthogonalized variables.

(20 out of 24 or 83%), NAM (79%) and GRO (79%). NRO exhibits the lowest number of times that is significantly correlated with macroeconomic indicators (58%). Comparing National liquidity (both NAM and NRO) and Global liquidity (both GAM and GRO), Global liquidity is correlated with macroeconomic indicators 39 out of 48 times (81%) while National liquidity correlated with macroeconomic indicators 33 times out of 48 or 68%.

In Australia, SD and DY present the highest number of correlations with macro indicators while EXR does not correlate with any of macro indicators. In Korea, volatility is correlated with all macroeconomic variables. In Hong Kong, Singapore, and Malaysia, DY presents the highest number of correlations with macroeconomic variables. In Philippines, EXR and DY are correlated with all macro variables while SD does not correlate with any of macro indicators. Overall, Dividend Yield is the variable that presents the highest correlation with the macroeconomic indicators (19 out of 24 or 79%) followed by volatility (19 out of 24 or 54%). Excess market returns show the weakest correlation with macroeconomic variables (7 out of 24 or 29%).

Panel C presents correlations between financial variables and liquidity variables. The number of significant correlations between financial variables and liquidity variables (both national and global) is varying across 6 countries. Volatility exhibits the highest number of correlations with liquidity (19 times out of 24 or 79%) followed by EXR (10 times out of 24 or 42%) and DY (9 times out of 24 or 37%). The number of significant correlations between financial variables and each liquidity proxy exhibits a similar result. AM (both NAM and GAM) correlates with financial variables 18 times out of 36 or 50% while RO (both NRO and GRO) correlates with financial variables 20 time out of 36 or 55%.

These results suggest that market volatility is the most important risk factor as the literature says that it cannot be diversified. Also, it shows that financial conditions are heavily relying on the economic performance. For instance, earnings for investors (excess market returns) and shareholders (dividend payment) are positively correlated with economic performance.

Table 5.2
Correlations of All Variables for All Six Countries

The table shows correlation coefficients between all variables used in our analysis. The associated p-values are reported in parentheses below each correlation coefficient. AM and RO are the 2 liquidity measures. SD is market volatility/standard deviation which is calculated as the cross sectional average volatility for all stocks in our sample, Dividend Yield (DY) and Excess market returns (EXR) are calculated as the value weighted returns in excess of the 3 month Treasury bill rate. GDP is real GDP growth, UN is growth in unemployment, CONS is real consumption growth, and INV is growth in investment. The prefix ‘N’ in front of each liquidity variable refers to national while the prefix ‘G’ refers to global. Global liquidity is created by combining all countries (The US and Japan are included) except the country nominated for the test. Correlations presented below are for raw data.

Panel A: correlations between macroeconomic variables and liquidity (National and Global)

	AUSTRALIA				HONG KONG				KOREA			
	GDP	UN	CONS	INV	GDP	UN	CONS	INV	GDP	UN	CONS	INV
NAM	**-0.627 (0.000)**	**0.597 (0.000)**	**-0.644 (0.000)**	**-0.614 (0.000)**	**-0.372 (0.001)**	**-0.201 (0.089)**	**-0.330 (0.004)**	**-0.348 (0.003)**	-0.179 (0.131)	**0.572 (0.000)**	**-0.235 (0.045)**	**-0.363 (0.002)**
NRO	-0.154 (0.193)	-0.017 (0.888)	-0.177 (0.133)	**-0.207 (0.079)**	-0.066 (0.577)	-0.179 (0.129)	-0.041 (0.730)	0.045 (0.703)	**-0.293 (0.012)**	**0.581 (0.000)**	**-0.325 (0.005)**	**-0.510 (0.000)**
GAM	**-0.394 (0.000)**	**0.446 (0.000)**	**-0.402 (0.000)**	**-0.346 (0.003)**	**-0.507 (0.000)**	-0.161 (0.173)	**-0.469 (0.000)**	-0.100 (0.399)	**-0.534 (0.000)**	-0.056 (0.637)	**-0.511 (0.000)**	**-0.394 (0.000)**
GRO	**-0.342 (0.003)**	**0.289 (0.013)**	**-0.361 (0.002)**	**-0.329 (0.004)**	**-0.374 (0.001)**	0.043 (0.717)	**-0.343 (0.003)**	**-0.263 (0.025)**	**-0.380 (0.001)**	**0.408 (0.000)**	**-0.399 (0.000)**	**-0.522 (0.000)**
	SINGAPORE				PHILIPPINES				MALAYSIA			
	GDP	UN	CONS	INV	GDP	UN	CONS	INV	GDP	UN	CONS	INV
NAM	-0.037 (0.752)	**0.408 (0.000)**	0.039 (0.744)	**-0.285 (0.014)**	**-0.319 (0.006)**	-0.050 (0.672)	**-0.363 (0.002)**	-0.023 (0.845)	**-0.389 (0.001)**	**0.371 (0.001)**	**-0.432 (0.000)**	**-0.628 (0.000)**
NRO	**-0.284 (0.014)**	**0.479 (0.000)**	**-0.225 (0.054)**	**-0.205 (0.079)**	**-0.279 (0.016)**	-0.032 (0.788)	**-0.312 (0.007)**	-0.115 (0.330)	**-0.404 (0.000)**	-0.089 (0.449)	**-0.412 (0.000)**	**-0.342 (0.003)**
GAM	**-0.522 (0.000)**	**-0.219 (0.059)**	**-0.576 (0.000)**	**-0.300 (0.009)**	**-0.495 (0.000)**	**0.343 (0.003)**	**-0.474 (0.000)**	**-0.505 (0.000)**	**-0.509 (0.000)**	**-0.348 (0.002)**	**-0.516 (0.000)**	-0.119 (0.314)
GRO	**-0.389 (0.000)**	-0.011 (0.925)	**-0.410 (0.000)**	-0.136 (0.247)	**-0.328 (0.004)**	0.166 (0.158)	**-0.307 (0.008)**	**-0.401 (0.004)**	**-0.364 (0.001)**	-0.016 (0.893)	**-0.367 (0.001)**	**-0.382 (0.001)**

Panel B: Correlations between macroeconomic variables and financial variables

	AUSTRALIA				HONG KONG				KOREA			
	GDP	UN	CONS	INV	GDP	UN	CONS	INV	GDP	UN	CONS	INV
SD	**0.390 (0.001)**	**-0.333 (0.004)**	**0.389 (0.001)**	**0.439 (0.000)**	-0.039 (0.746)	-0.159 (0.179)	0.019 (0.873)	0.081 (0.499)	**-0.273 (0.020)**	**0.356 (0.002)**	**-0.288 (0.014)**	**-0.431 (0.000)**
EXR	-0.039 (0.742)	0.046 (0.698)	-0.043 (0.719)	-0.068 (0.569)	0.055 (0.647)	**-0.242 (0.041)**	0.034 (0.779)	0.053 (0.658)	0.085 (0.477)	**0.282 (0.016)**	0.069 (0.561)	-0.006 (0.963)
DY	**0.492 (0.000)**	**-0.250 (0.034)**	**0.497 (0.000)**	**0.571 (0.000)**	**-0.216 (0.069)**	0.193 (0.104)	**-0.215 (0.069)**	**-0.206 (0.083)**	-0.013 (0.917)	**-0.289 (0.014)**	0.015 (0.903)	0.120 (0.314)

	SINGAPORE				PHILIPPINES				MALAYSIA			
	GDP	UN	CONS	INV	GDP	UN	CONS	INV	GDP	UN	CONS	INV
SD	**-0.197 (0.094)**	0.096 (0.417)	**-0.236 (0.044)**	-0.020 (0.865)	-0.166 (0.161)	-0.099 (0.402)	-0.175 (0.139)	-0.127 (0.284)	**-0.429 (0.000)**	-0.157 (0.187)	**-0.423 (0.000)**	**-0.305 (0.009)**
EXR	0.068 (0.567)	0.100 (0.398)	0.066 (0.579)	-0.012 (0.919)	**-0.714 (0.000)**	**0.952 (0.000)**	**-0.657 (0.000)**	**-0.698 (0.000)**	0.088 (0.461)	**0.214 (0.071)**	0.085 (0.480)	-0.038 (0.755)
DY	**0.588 (0.000)**	**0.435 (0.000)**	**0.623 (0.000)**	**0.493 (0.000)**	**0.727 (0.000)**	**-0.399 (0.000)**	**0.731 (0.000)**	**0.504 (0.000)**	**0.616 (0.000)**	**0.448 (0.000)**	**0.604 (0.000)**	0.084 (0.481)

Panel C: Correlations between financial variables and liquidity variables (National and Global)

	AUSTRALIA				HONG KONG				KOREA			
	NAM	NRO	GAM	GRO	NAM	NRO	GAM	GRO	NAM	NRO	GAM	GRO
SD	-0.076 (0.523)	**0.427 (0.000)**	-0.135 (0.255)	**0.346 (0.003)**	0.010 (0.931)	**0.544 (0.000)**	**0.319 (0.006)**	**0.729 (0.000)**	0.019 (0.871)	**0.662 (0.000)**	**0.239 (0.041)**	**0.669 (0.000)**
EXR	-0.045 (0.703)	**-0.325 (0.005)**	0.078 (0.509)	**-0.257 (0.028)**	**0.418 (0.000)**	0.057 (0.630)	-0.027 (0.823)	0.064 (0.589)	-0.123 (0.298)	0.003 (0.979)	**-0.205 (0.082)**	-0.163 (0.167)
DY	**-0.239 (0.042)**	-0.146 (0.217)	-0.088 (0.461)	-0.183 (0.122)	0.121 (0.309)	0.174 (0.142)	**0.244 (0.038)**	0.177 (0.133)	0.092 (0.440)	-0.065 (0.584)	**0.281 (0.016)**	0.087 (0.642)
	SINGAPORE				PHILIPPINES				MALAYSIA			
	NAM	NRO	GAM	GRO	NAM	NRO	GAM	GRO	NAM	NRO	GAM	GRO
SD	**-0.201 (0.086)**	**0.776 (0.000)**	**0.339 (0.003)**	**0.787 (0.000)**	**0.237 (0.042)**	**0.336 (0.003)**	0.175 (0.136)	**0.627 (0.000)**	**0.458 (0.000)**	**0.921 (0.000)**	**-0.420 (0.000)**	**0.665 (0.000)**
EXR	-0.051 (0.665)	**-0.275 (0.018)**	-0.169 (0.149)	**-0.235 (0.044)**	0.054 (0.648)	0.053 (0.655)	**0.347 (0.002)**	0.091 (0.439)	**-0.321 (0.006)**	**-0.315 (0.007)**	0.082 (0.489)	**-0.329 (0.005)**
DY	0.163 (0.166)	**0.214 (0.068)**	**-0.251 (0.031)**	-0.044 (0.709)	**-0.281 (0.015)**	**-0.234 (0.045)**	**-0.199 (0.089)**	0.129 (0.270)	0.078 (0.509)	-0.028 (0.813)	**0.627 (0.000)**	0.089 (0.449)

5.3. PREDICTING ECONOMIC GROWTH WITH MARKET ILLIQUIDITY

5.3.1 IN SAMPLE EVIDENCE

This section explores whether market illiquidity contains information about expected economic growth. We estimate the following regression model.

$$Y_{t+1} = \alpha + \beta LIQ_t + \delta LIQ_{t-1} + \gamma' X_t + u_{t+1} \quad (5.2)$$

Where Y_{t+1} is the realised growth of macroeconomic variables one quarter ahead (t+1) such as real GDP growth, growth in the unemployment rate (UN), real consumption growth (CONS), and growth in private investment (INV). LIQ_t is the national market illiquidity for the contemporaneous quarter and LIQ_{t-1} is the national market illiquidity for quarter t-1. Since the model regress the liquidity variables on the dependent variable at t+1, the model contains two lags of liquidity variables. Illiquidity measures are captured by the national Amihud ratio (NAM) and the national Roll measure (NRO). X_t presents the control variables which are excess market returns (EXR), volatility (SD), one lag of the dependent variable (DEP), dividend yield (DY), and Global liquidity (GAM and GRO). Global liquidity is created by combining all countries' (the US and Japan are also included) liquidity following Brockman et al (2009) except the country nominated for the test. γ' is the vector of coefficient estimates for the control variables and u_{t+1} is the error term. All dependent variables are orthogonalized to avoid multicollinearity.

In order to identify the contribution of national and global liquidity on the model, it estimates the regression with three different model specifications. The first regression specification always includes two lags of the national liquidity variable

(NAM or NRO) and financial variables. Next, global liquidity (GAM or GRO) is included in the model instead of national liquidity with the same financial variables as before. The third specification includes all liquidity variables (national and global liquidity) and financial variables. Table 5.3 presents adjusted R^2 with and without liquidity variables (national and global). Panel A presents results for each individual country while panel B summarizes results for all countries.

Panel B presents grand averages of adjusted R^2 and proportional contribution associated with each variable. It is mainly interested in the bottom two rows. More specifically, none of liquidity variables (NAM and GAM) have extra explanatory power over financial variables (penultimate row). However, when the model uses RO, NRO does increase adjusted R^2 by 1% and GRO increase adjusted R^2 value by 2%. Even though small changes in adjusted R^2 value, it implies that liquidity variables have extra information after controlling the financial variables. It is evident that the ROLL measure performs better than the Amihud-ratio. Noticeably, GRO contains more information than any other variable. This implies that global liquidity is a more important factor in predicting macroeconomic variables than national liquidity.

In order to investigate the impact of liquidity on macroeconomic variables in more detail, the study regroups the 6 countries as developed market and developing markets. The groups are based on FTSE country classification. Developed markets are Australia, Hong Kong, Korea, and Singapore and developing markets are Philippines and Malaysia. As it can see from the last two rows in panel C and panel D, the grand average in panel C (developed markets) shows that the explanatory power associated with AM is increasing when it adds NAM (by 1%) and GAM (by 1%) over the financial variables. When it comes to RO, it observes a higher percentage increase in R^2 adj compared to AM. R^2 adj increase by 2% when it adds NRO and by 3% when it adds GRO. In the developing markets group (panel D), NAM and GAM do not add any explanatory power over financial variables. On the other hand, when RO is used, it increases R^2 adj. GRO increases R^2 adj by 3% while NRO increases R^2 adj by 1%. This clearly shows that the ROLL measure outperforms the Amihud-ratio in explaining macroeconomic variables in both developed and developing markets. Now it compares explanatory power between national liquidity and global liquidity. For developed markets, global liquidity performs slightly better than national liquidity, especially when is uses RO. For developing markets, global liquidity outperforms national liquidity as well.

Overall, the results indicate that control variables are important factors for all countries. Liquidity variables are also important in explaining macroeconomic variables especially global liquidity. Also RO outperforms AM. This is consistently found in developed markets. It can be explained by the specification of liquidity measure. For instance, the AM cannot distinguish between temporary lack of liquidity and permanent price effect while RO can capture the temporary shortage of liquidity. Thus, the economic performance explained by RO is better than explained by AM. AM For developing markets, however, global liquidity measured by RO is the only variable that increases explanatory power while national liquidity does not have an impact on macroeconomic variables.

5.3.1.1 CAUSALITY

Predicting macroeconomic variables with liquidity is the main concern in this paper. Goyenko, Subrahmanyam, and Ukhov (2011) investigate if there is a one way causal relation between economic variables and bond liquidity (short and medium term bond) for the US. They find that all four economic variables (volatility, term premium, default premium, and monetary policy) do Granger cause bond market illiquidity (proportional spread). A recent study by NSO (2011) shows a one way relationship between illiquidity and macroeconomic variables while G&G (2013) show that there is a two way relationship but they also emphasize the small effect of macroeconomic variables on liquidity[32]. Thus, this study tests for a two-way relationship between illiquidity (National and Global) and macro variables for six Asian countries (Australia, Hong Kong, Korea, Philippines, Singapore, and Malaysia). This study could give us a much clearer picture of the relation between liquidity and macro variables in global scale.

[32] NSO (2011) investigate for the US market and G&G (2013) covers six countries namely the UK, Canada, France, Germany, Italy, and Japan.

Table 5.3
In Sample Prediction Macro Variables

The table shows the results from predictive regression where we regress next quarter growth in different macro variables ($GDP_{t+1,}$ $INV_{t+1,}$ $CONS_{t+1}$ and UN_{t+1}) on 2 proxies for market illiquidity. Market illiquidity (LIQ) is captured by the Amihud ratio (AM) and Roll's effective spread (RO). The prefix 'N' means national and the prefix 'G' means global The cross sectional liquidity measures are calculated as equally weighted averages across stocks. The model estimated is $Y_{t+1}= \alpha + \beta LIQ_t + \delta LIQ_{t-1} + \gamma' \mathbf{X}_t + u_{t+1}$ where Y_{t+1} is real GDP growth $GDP_{t+1,}$ investment growth $INV_{t+1,}$ real consumption growth $CONS_{t+1}$ and growth in the unemployment rate UN_{t+1}. We also include one lag of the dependent variable which we call DEP and EXR, DY, SD and GLOBAL are our control variables. Global liquidity is created by combining all countries (The US and Japan are included) except the country nominated for the test. The number in parentheses is the p-value. The column on the far right labelled R^2Adj. EX L is the adjusted R^2 without the liquidity variable. Panel B, C, and D summarizes all results obtained from previous panels.

Panel A

Hong Kong	CON	NAM_t	NAM_{t-1}	DEP_t	EXR_t	SD_t	DY_t	GAM_t	R^2 adj	R^2 adj EX
GDP_{t+1}	0.029 (0.348)	-0.014 (0.205)	**-0.021 (0.048)**	-0.073 (0.545)	-0.007 (0.882)	**-1.807 (0.056)**	0.002 (0.864)		0.057	0.021
	0.025 (0.443)			-0.073 (0.553)	-0.033 (0.461)	**-1.977 (0.041)**	0.004 (0.661)	-0.006 (0.890)	0.006	0.006
	0.029 (0.351)	-0.014 (0.204)	**-0.021 (0.049)**	-0.071 (0.562)	-0.007 (0.881)	**-1.804 (0.059)**	0.002 (0.867)	-0.008 (0.834)	0.043	0.006
UN_{t+1}	-0.015 (0.790)	-0.007 (0.655)	**0.029 (0.072)**	**0.521 (0.000)**	-0.045 (0.498)	**6.212 (0.000)**	-0.023 (0.180)		0.509	0.489
	-0.024 (0.677)			**0.512 (0.000)**	-0.017 (0.785)	**6.428 (0.000)**	-0.022 (0.199)	**0.131 (0.027)**	0.519	0.519
	-0.009 (0.861)	-0.005 (0.759)	**0.029 (0.055)**	**0.543 (0.000)**	-0.043 (0.502)	**6.090 (0.000)**	-0.025 (0.143)	**0.130 (0.025)**	0.540	0.519
$CONS_{t+1}$	**0.044 (0.028)**	-0.009 (0.183)	**-0.018 (0.009)**	**-0.675 (0.000)**	0.019 (0.491)	**-1.985 (0.001)**	-0.002 (0.809)		0.528	0.489
	0.041 (0.049)			**-0.669 (0.000)**	-0.0004 (0.989)	**-2.119 (0.001)**	0.0003 (0.954)	0.004 (0.863)	0.481	0.481
	0.044 (0.029)	-0.009 (0.189)	**-0.018 (0.010)**	**-0.675 (0.000)**	0.019 (0.493)	**-1.985 (0.001)**	-0.002 (0.812	0.003 (0.909)	0.521	0.481
INV_{t+1}	0.057 (0.133)	-0.008 (0.531)	-0.013 (0.297)	**-0.329 (0.010)**	-0.001 (0.981)	-1.532 (0.168)	-0.009 (0.459)		0.045	0.056
	0.054 (0.151)			**-0.324 (0.012)**	-0.017 (0.733)	-1.626 (0.142)	-0.007 (0.539)	-0.016 (0.727)	0.044	0.044
	0.057 (0.137)	-0.008 (0.519)	-0.013 (0.298)	**-0.325 (0.012)**	-0.002 (0.976)	-1.523 (0.173)	-0.009 (0.462)	-0.018 (0.705)	0.031	0.044
	CON	NRO_t	NRO_{t-1}	DEP_t	EXR_t	SD_t	DY_t	GRO_t	R^2 adj	R^2 adj EX
GDP_{t+1}	0.036 (0.279)	-0.029 (0.176)	-0.018 (0.395)	-0.041 (0.746)	-0.024 (0.603)	**-1.851 (0.055)**	-6.7E-5 (0.995)		0.021	0.021
	0.025 (0.442)			-0.072 (0.554)	-0.033 (0.460)	**-1.981 (0.041)**	0.004 (0.659)	-1.745 (0.690)	0.008	0.008
	0.036 (0.272)	-0.031 (0.160)	-0.019 (0.359)	-0.037 (0.769)	-0.024 (0.617)	**-1.849 (0.057)**	-0.0003 (0.975)	-2.633 (0.552)	0.011	0.008
UN_{t+1}	-0.033 (0.574)	-0.049 (0.144)	-0.032 (0.324)	**0.418 (0.001)**	-0.004 (0.956)	**7.038 (0.000)**	-0.022 (0.215)		0.491	0.489
	-0.029 (0.626)			**0.494 (0.000)**	-0.021 (0.741)	**6.517 (0.000)**	-0.021 (0.249)	-1.027 (0.875)	0.481	0.481
	-0.031 (0.599)	-0.049 (0.144)	-0.032 (0.318)	**0.422 (0.001)**	-0.004 (0.957)	**7.016 (0.000)**	-0.022 (0.212)	-1.670 (0.799)	0.483	0.481
$CONS_{t+1}$	**0.039 (0.063)**	0.011 (0.460)	-0.007 (0.612)	**-0.708 (0.000)**	0.007 (0.816)	**-2.168 (0.001)**	0.001 (0.879)		0.483	0.489
	0.041 (0.049)			**-0.669 (0.000)**	-0.001 (0.984)	**2.119 (0.001)**	0.0003 (0.955)	0.006 (0.998)	0.481	0.481
	0.039 (0.065)	0.010 (0.467)	-0.007 (0.613)	**-0.709 (0.000)**	0.007 (0.817)	**-2.169 (0.001)**	0.001 (0.882)	-0.137 (0.962)	0.475	0.481
INV_{t+1}	0.039 (0.307)	0.033 (0.165)	0.034 (0.159)	**-0.037 (0.008)**	-0.037 (0.494)	-1.769 (0.107)	-0.001 (0.918)		0.069	0.056
	0.058 (0.120)			**-0.361 (0.005)**	-0.019 (0.692)	-1.711 (0.116)	-0.008 (0.498)	**-8.210 (0.099)**	0.082	0.082
	0.044 (0.251)	0.029 (0.218)	0.029 (0.215)	**-0.368 (0.004)**	-0.037 (0.489)	**-1.822 (0.095)**	-0.002 (0.839)	-7.198 (0.151)	0.085	0.082

KOREA	CON	NAM_t	NAM_{t-1}	DEP_t	EXR_t	SD_t	DY_t	GAM_t	R^2 adj	R^2 adj EX
GDP_{t+1}	**0.009 (0.000)**	0.007 (0.215)	0.002 (0.766)	0.152 (0.190)	0.020 (0.135)	**-0.018 (0.001)**	**-0.010 (0.006)**		0.329	0.307
	0.009 (0.000)			0.179 (0.120)	0.019 (0.102)	**-0.018 (0.000)**	**-0.009 (0.012)**	-0.011 (0.346)	0.306	0.306
	0.009 (0.000)	0.007 (0.218)	0.001 (0.833)	0.168 (0.157)	0.020 (0.128)	**-0.018 (0.001)**	**-0.009 (0.008)**	-0.008 (0.483)	0.323	0.306
UN_{t+1}	0.002 (0.941)	-0.001 (0.992)	0.003 (0.968)	-0.106 (0.381)	-0.078 (0.651)	**0.166 (0.009)**	**0.095 (0.034)**		0.092	0.119
	0.001 (0.949)			-0.106 (0.361)	-0.073 (0.621)	**0.167 (0.007)**	**0.095 (0.028)**	0.166 (0.233)	0.126	0.126

	0.001 (0.948)	0.003 (0.971)	0.009 (0.905)	-0.106 (0.377)	-0.079 (0.644)	**0.168** **(0.009)**	**0.095** **(0.032)**	0.169 (0.234)	0.098	0.126
$CONS_{t+1}$	**0.007** **(0.004)**	0.001 (0.941)	0.010 (0.163)	**0.191** **(0.072)**	0.014 (0.447)	**-0.029** **(0.000)**	**-0.013** **(0.006)**		0.384	0.365
	0.007 **(0.006)**			**0.227** **(0.029)**	0.024 (0.129)	**-0.029** **(0.000)**	**-0.013** **(0.005)**	-0.021 (0.156)	0.375	0.375
	0.007 **(0.004)**	0.0002 (0.976)	0.009 (0.188)	**0.192** **(0.069)**	0.014 (0.438)	**-0.029** **(0.000)**	**-0.013** **(0.006)**	-0.017 (0.233)	0.388	0.375
INV_{t+1}	0.003 (0.337)	0.003 (0.772)	0.008 (0.529)	0.179 (0.140)	0.009 (0.745)	**-0.029** **(0.008)**	**-0.021** **(0.008)**		0.237	0.244
	0.003 (0.335)			**0.199** **(0.082)**	0.015 (0.539)	**-0.030** **(0.005)**	**-0.021** **(0.006)**	**-0.048** **(0.043)**	0.279	0.279
	0.003 (0.334)	0.003 (0.793)	0.006 (0.630)	**0.197** **(0.099)**	0.011 (0.702)	**-0.029** **(0.007)**	**-0.020** **(0.008)**	**-0.045** **(0.062)**	0.267	0.279
	CON	NRO_t	NRO_{t-1}	DEP_t	EXR_t	SD_t	DY_t	GRO_t	R^2 adj	R^2 adj EX
GDP_{t+1}	**0.009** **(0.000)**	0.001 (0.916)	**0.026** **(0.037)**	**0.201** **(0.087)**	**0.021** **(0.070)**	**-0.021** **(0.000)**	**-0.009** **(0.008)**		0.350	0.307
	0.009 **(0.000)**			0.151 (0.201)	0.019 (0.112)	**-0.019** **(0.000)**	**-0.009** **(0.009)**	-0.247 (0.754)	0.297	0.297
	0.009 **(0.000)**	0.003 (0.858)	**0.027** **(0.003)**	0.189 (0.117)	**0.020** **(0.082)**	**-0.021** **(0.000)**	**-0.009** **(0.008)**	-0.397 (0.608)	0.343	0.297
UN_{t+1}	0.001 (0.949)	-0.033 (0.854)	-0.208 (0.197)	-0.072 (0.554)	-0.086 (0.562)	**0.192** **(0.006)**	**0.096** **(0.026)**		0.121	0.119
	0.001 (0.954)			-0.141 (0.230)	-0.056 (0.701)	**0.165** **(0.008)**	**0.095** **(0.025)**	15.539 (0.109)	0.141	0.141
	0.0003 (0.984)	-0.094 (0.602)	-0.254 (0.114)	-0.099 (0.408)	-0.059 (0.688)	**0.201** **(0.004)**	**0.098** **(0.021)**	**17.534** **(0.076)**	0.152	0.141
$CONS_{t+1}$	**0.006** **(0.007)**	0.029 (0.115)	**0.044** **(0.008)**	**0.286** **(0.008)**	0.024 (0.117)	**-0.036** **(0.000)**	**-0.014** **(0.003)**		0.415	0.365
	0.006 **(0.007)**			**0.229** **(0.035)**	0.025 (0.131)	**-0.029** **(0.000)**	**-0.013** **(0.006)**	0.071 (0.945)	0.355	0.355
	0.006 **(0.007)**	0.031 (0.109)	**0.045** **(0.008)**	**0.279** **(0.011)**	0.023 (0.135)	**-0.036** **(0.000)**	**-0.014** **(0.003)**	-0.402 (0.693)	0.407	0.355
INV_{t+1}	0.003 (0.362)	-0.011 (0.729)	0.023 (0.395)	0.183 (0.128)	0.018 (0.470)	**-0.032** **(0.007)**	**-0.021** **(0.007)**		0.239	0.244
	0.004 (0.318)			0.153 (0.207)	0.013 (0.604)	**-0.031** **(0.005)**	**-0.022** **(0.006)**	-1.421 (0.406)	0.240	0.240
	0.003 (0.333)	-0.006 (0.846)	0.027 (0.329)	0.157 (0.204)	0.016 (0.541)	**-0.033** **(0.006)**	**-0.022** **(0.006)**	-1.544 (0.376)	0.237	0.240

Australia	CON	NAM_t	NAM_{t-1}	DEP_t	EXR_t	SD_t	DY_t	GAM_t	R^2 adj	R^2 adj EX
GDP_{t+1}	**0.009** **(0.000)**	-0.0002 (0.889)	0.002 (0.155)	-0.158 (0.215)	1.004 (0.111)	8.5E-05 (0.906)	-0.0003 (0.975)		0.007	-0.001
	0.009 **(0.000)**			-0.181 (0.158)	0.979 (0.129)	0.0001 (0.851)	-0.001 (0.912)	-0.0001 (0.909)	-0.016	-0.016
	0.009 **(0.000)**	-0.0001 (0.889)	0.002 (0.159)	-0.159 (0.219)	1.008 (0.119)	8.2E-05 (0.911)	-0.0003 (0.974)	3.5E-05 (0.973)	-0.009	-0.016
UN_{t+1}	**-0.011** **(0.017)**	-0.001 (0.864)	0.009 (0.181)	-0.051 (0.679)	**-21.08** **(0.000)**	-0.0003 (0.936)	0.094 (0.101)		0.338	0.334
	-0.011 **(0.018)**			-0.050 (0.662)	**-21.37** **(0.000)**	-0.0002 (0.973)	0.089 (0.118)	-0.001 (0.909)	0.323	0.323
	-0.011 **(0.018)**	-0.001 (0.866)	0.009 (0.186)	-0.051 (0.682)	**-21.06** **(0.000)**	-0.0003 (0.932)	0.094 (0.104)	0.0003 (0.965)	0.327	0.323
$CONS_{t+1}$	**0.007** **(0.000)**	0.001 (0.353)	-0.001 (0.625)	0.192 (0.129)	**1.070** **(0.069)**	-0.001 (0.121)	0.001 (0.874)		0.075	0.079
	0.007 **(0.000)**			0.178 (0.159)	**1.125** **(0.060)**	-0.001 (0.102)	0.001 (0.892)	0.0003 (0.746)	0.067	0.067
	0.007 **(0.000)**	0.001 (0.354)	-0.0005 (0.647)	0.193 (0.131)	**1.094** **(0.069)**	-0.001 (0.119)	0.001 (0.884)	0.0002 (0.801)	0.061	0.067
INV_{t+1}	**0.028** **(0.000)**	0.003 (0.727)	-0.007 (0.443)	**-0.369** **(0.003)**	-0.867 (0.862)	0.009 (0.132)	0.008 (0.912)		0.084	-0.029
	0.028 **(0.000)**			**-0.379** **(0.002)**	-0.929 (0.854)	0.009 (0.129)	0.013 (0.851)	-0.002 (0.779)	0.085	0.085
	0.028 **(0.000)**	0.003 (0.732)	-0.007 (0.427)	**-0.372** **(0.003)**	-1.179 (0.817)	0.009 (0.125)	0.009 (0.896)	-0.003 (0.712)	0.072	0.085
	CON	NRO_t	NRO_{t-1}	DEP_t	EXR_t	SD_t	DY_t	GRO_t	R^2 adj	R^2 adj EX
GDP_{t+1}	**0.009** **(0.000)**	0.005 (0.294)	0.003 (0.499)	-0.207 (0.112)	**1.072** **(0.095)**	0.0003 (0.706)	-0.001 (0.919)		-0.013	-0.001
	0.009 **(0.000)**			-0.185 (0.148)	0.981 (0.122)	8.2E-05 (0.910)	-0.001 (0.902)	0.179 (0.606)	-0.012	-0.012
	0.009 **(0.000)**	0.005 (0.287)	0.004 (0.452)	-0.212 (0.106)	**1.066** **(0.098)**	0.0002 (0.749)	-0.001 (0.912)	0.212 (0.548)	-0.023	-0.012
UN_{t+1}	**-0.011** **(0.019)**	0.002 (0.955)	0.004 (0.897)	-0.049 (0.673)	**-21.26** **(0.000)**	-0.0001 (0.976)	0.089 (0.123)		0.313	0.334
	-0.011 **(0.018)**			-0.049 (0.665)	**-21.29** **(0.000)**	-0.0002 (0.966)	0.089 (0.119)	-0.152 (0.942)	0.323	0.323
	-0.011 **(0.020)**	0.002 (0.956)	0.004 (0.905)	-0.049 (0.678)	**-21.25** **(0.000)**	-0.0001 (0.981)	0.089 (0.126)	-0.118 (0.956)	0.301	0.323
$CONS_{t+1}$	**0.007** **(0.000)**	0.004 (0.369)	0.002 (0.660)	0.176 (0.166)	**1.132** **(0.058)**	-0.001 (0.149)	0.001 (0.877)		0.063	0.079
	0.007 **(0.000)**			0.176 (0.161)	**1.085** **(0.066)**	**-0.001** **(0.099)**	0.001 (0.886)	0.150 (0.639)	0.069	0.069
	0.007 **(0.000)**	0.004 (0.366)	0.002 (0.615)	0.175 (0.172)	**1.124** **(0.061)**	-0.001 (0.139)	0.001 (0.887)	0.167 (0.609)	0.052	0.069
INV_{t+1}	**0.028** **(0.000)**	0.038 (0.352)	**0.090** **(0.027)**	**-0.388** **(0.001)**	0.214 (0.965)	**0.011** **(0.059)**	**0.010** **(0.059)**		0.140	0.098

	0.029 (0.000)			**-0.467 (0.000)**	-0.024 (0.996)	**0.012 (0.035)**	0.022 (0.729)	**-8.684 (0.002)**	0.213	0.213
	0.030 (0.000)	0.040 (0.292)	**0.075 (0.052)**	**-0.474 (0.000)**	0.724 (0.874)	0.021 (0.741)	**0.014 (0.016)**	**-8.049 (0.004)**	0.238	0.213

Malaysia	CON	NAM_t	NAM_{t-1}	DEP_t	EXR_t	SD_t	DY_t	GAM_t	R^2 adj	R^2 adj EX
	0.015 (0.000)	-0.279 (0.289)	**0.443 (0.097)**	-0.141 (0.216)	**0.136 (0.036)**	0.007 (0.391)	**-0.081 (0.001)**		0.145	0.184
GDP_{t+1}	**0.015 (0.001)**			-0.118 (0.301)	**0.125 (0.056)**	0.006 (0.487)	**-0.075 (0.002)**	0.005 (0.852)	0.121	0.121
	0.015 (0.000)	-0.294 (0.271)	**0.464 (0.088)**	-0.148 (0.199)	**0.139 (0.034)**	0.007 (0.439)	**-0.081 (0.001)**	0.012 (0.635)	0.135	0.121
	-0.003 (0.805)	-0.486 (0.556)	0.210 (0.799)	-0.095 (0.429)	-0.307 (0.111)	0.009 (0.714)	**0.221 (0.002)**		0.099	0.138
UN_{t+1}	-0.003 (0.799)			-0.115 (0.316)	-0.314 (0.101)	0.008 (0.744)	**0.223 (0.002)**	0.005 (0.944)	0.125	0.125
	-0.003 (0.805)	-0.492 (0.556)	0.221 (0.792)	-0.096 (0.430)	-0.306 (0.118)	0.009 (0.729)	**0.222 (0.003)**	0.007 (0.923)	0.102	0.125
	0.015 (0.011)	0.047 (0.893)	0.099 (0.779)	-0.039 (0.753)	0.118 (0.166)	-0.011 (0.347)	2.3E05 (0.999)		-0.043	-0.015
$CONS_{t+1}$	**0.015 (0.010)**			-0.041 (0.739)	0.114 (0.177)	0.001 (0.982)	-0.011 (0.352)	-0.009 (0.789)	-0.029	-0.029
	0.015 (0.011)	0.054 (0.880)	0.088 (0.808)	-0.041 (0.742)	0.116 (0.179)	-0.010 (0.371)	-0.0003 (0.994)	-0.008 (0.823)	-0.059	-0.029
	0.011 (0.299)	-0.363 (0.629)	1.069 (0.148)	-0.129 (0.327)	**0.295 (0.082)**	0.029 (0.179)	**-0.169 (0.007)**		0.093	0.086
INV_{t+1}	0.011 (0.296)			-0.101 (0.390)	0.245 (0.139)	0.032 (0.140)	**-0.161 (0.009)**	-0.103 (0.115)	0.107	0.107
	0.011 (0.281)	-0.303 (0.685)	0.943 (0.201)	-0.138 (0.289)	0.276 (0.103)	0.034 (0.127)	**-0.174 (0.006)**	-0.091 (0.163)	0.107	0.107
	CON	NRO_t	NRO_{t-1}	DEP_t	EXR_t	SD_t	DY_t	GRO_t	R^2 adj	R^2 adj EX
	0.015 (0.001)	-0.019 (0.429)	-0.007 (0.763)	-0.095 (0.411)	**0.127 (0.053)**	0.007 (0.439)	**-0.075 (0.003)**		0.117	0.134
GDP_{t+1}	**0.015 (0.000)**			-0.139 (0.211)	0.096 (0.141)	0.009 (0.286)	**-0.081 (0.001)**	**-3.598 (0.077)**	0.162	0.162
	0.015 (0.001)	-0.021 (0.368)	-0.009 (0.686)	-0.118 (0.305)	0.098 (0.136)	0.009 (0.265)	**-0.081 (0.001)**	**-3.685 (0.074)**	0.178	0.162
	-0.003 (0.823)	0.003 (0.969)	0.059 (0.410)	-0.101 (0.381)	-0.302 (0.115)	0.007 (0.774)	**0.204 (0.006)**		0.126	0.138
UN_{t+1}	-0.003 (0.787)			-0.159 (0.157)	-0.207 (0.274)	-0.003 (0.893)	**0.242 (0.001)**	**13.412 (0.028)**	0.188	0.188
	-0.003 (0.814)	0.014 (0.835)	0.067 (0.337)	-0.145 (0.201)	-0.196 (0.306)	-0.005 (0.841)	**0.223 (0.002)**	**13.547 (0.028)**	0.178	0.188
	0.014 (0.012)	-0.002 (0.939)	-0.018 (0.573)	-0.032 (0.793)	0.114 (0.183)	-0.010 (0.356)	0.007 (0.832)		-0.039	-0.015
$CONS_{t+1}$	**0.015 (0.007)**			-0.062 (0.603)	0.072 (0.396)	-0.007 (0.529)	-0.007 (0.822)	**-5.090 (0.059)**	0.025	0.025
	0.015 (0.009)	-0.006 (0.833)	-0.021 (0.493)	-0.055 (0.649)	0.069 (0.419)	-0.006 (0.580)	-0.001 (0.981)	**-5.166 (0.059)**	0.003	0.025
	0.010 (0.318)	-0.016 (0.794)	0.035 (0.574)	-0.083 (0.485)	0.275 (0.106)	0.027 (0.232)	**-0.169 (0.009)**		0.071	0.086
INV_{t+1}	0.011 (0.292)			-0.121 (0.302)	0.181 (0.282)	0.035 (0.107)	**-0.173 (0.005)**	**-10.652 (0.046)**	0.127	0.127
	0.011 (0.290)	-0.025 (0.677)	0.027 (0.657)	-0.121 (0.307)	0.194 (0.253)	0.035 (0.118)	**-0.186 (0.004)**	**-10.703 (0.048)**	0.114	0.127

Philippines	CON	NAM_t	NAM_{t-1}	DEP_t	EXR_t	SD_t	DY_t	GAM_t	R^2 adj	R^2 adj EX
	0.046 (0.008)	0.003 (0.765)	0.010 (0.332)	**-0.813 (0.000)**	**-0.101 (0.006)**	**-2.350 (0.081)**	0.043 (0.270)		0.568	0.575
GDP_{t+1}	**0.046 (0.009)**			**-0.794 (0.000)**	**-0.094 (0.008)**	**-2.299 (0.089)**	0.034 (0.368)	0.038 (0.591)	0.570	0.570
	0.044 (0.012)	0.004 (0.730)	0.012 (0.277)	**-0.817 (0.000)**	**-0.102 (0.005)**	-2.191 (0.109)	0.044 (0.259)	0.054 (0.463)	0.565	0.570
	-0.101 (0.041)	0.041 (0.163)	-0.028 (0.336)	-0.310 (0.432)	0.005 (0.987)	**8.199 (0.036)**	-0.071 (0.562)		0.203	0.162
UN_{t+1}	**-0.089 (0.077)**			-0.597 (0.126)	0.218 (0.499)	**7.333 (0.069)**	-0.091 (0.469)	-0.184 (0.359)	0.160	0.160
	-0.091 (0.065)	0.038 (0.192)	-0.033 (0.253)	-0.324 (0.411)	0.019 (0.953)	**7.464 (0.058)**	-0.077 (0.528)	-0.224 (0.259)	0.206	0.160
	0.038 (0.053)	-0.0003 (0.979)	0.008 (0.489)	**-0.853 (0.000)**	**-0.088 (0.025)**	-1.402 (0.351)	0.022 (0.623)		0.661	0.668
$CONS_{t+1}$	**0.036 (0.063)**			**-0.838 (0.000)**	**-0.083 (0.031)**	-1.292 (0.390)	0.014 (0.742)	0.062 (0.437)	0.667	0.667
	0.035 (0.077)	0.0004 (0.975)	0.010 (0.392)	**-0.858 (0.000)**	**-0.089 (0.024)**	-1.174 (0.440)	0.023 (0.598)	0.077 (0.353)	0.661	0.667
	0.047 (0.058)	0.012 (0.418)	0.016 (0.304)	**-0.273 (0.011)**	**-0.259 (0.000)**	**-3.305 (0.088)**	0.071 (0.209)		0.278	0.287
INV_{t+1}	**0.049 (0.050)**			**-0.263 (0.016)**	**-0.250 (0.000)**	**-3.432 (0.079)**	0.059 (0.283)	-0.015 (0.884)	0.276	0.276
	0.047 (0.064)	0.013 (0.422)	0.016 (0.313)	**-0.273 (0.013)**	**-0.259 (0.000)**	**-3.299 (0.095)**	0.071 (0.213)	0.002 (0.987)	0.266	0.276
	CON	NRO_t	NRO_{t-1}	DEP_t	EXR_t	SD_t	DY_t	GRO_t	R^2 adj	R^2 adj EX

GDP_{t+1}	**0.042 (0.017)**	**2.169 (0.076)**	-1.399 (0.285)	**-0.783 (0.000)**	**-0.101 (0.004)**	-2.013 (0.139)	0.043 (0.255)		0.589	0.575
	0.047 (0.007)			**-0.789 (0.000)**	**-0.093 (0.008)**	**-2.431 (0.069)**	0.036 (0.338)	-2.835 (0.503)	0.571	0.571
	0.043 (0.016)	**2.165 (0.078)**	-1.351 (0.304)	**-0.781 (0.000)**	**-0.101 (0.004)**	-2.049 (0.135)	0.045 (0.240)	-2.571 (0.537)	0.585	0.571
UN_{t+1}	**-0.091 (0.081)**	-4.821 (0.169)	1.279 (0.729)	-0.643 (0.101)	0.269 (0.408)	**7.372 (0.075)**	-0.108 (0.399)		0.162	0.162
	-0.097 (0.056)			-0.600 (0.132)	0.221 (0.503)	**7.889 (0.049)**	-0.095 (0.457)	4.054 (0.738)	0.151	0.151
	-0.090 (0.084)	-4.843 (0.169)	1.206 (0.747)	**-0.669 (0.096)**	0.291 (0.384)	**7.342 (0.078)**	-0.115 (0.378)	4.197 (0.729)	0.151	0.151
$CONS_{t+1}$	**0.034 (0.085)**	2.047 (0.138)	-1.296 (0.379)	**-0.833 (0.000)**	**-0.091 (0.019)**	0.023 (0.595)	-1.112 (0.468)		0.673	0.668
	0.038 (0.048)			**-0.834 (0.000)**	**-0.083 (0.032)**	-1.473 (0.324)	0.015 (0.727)	-1.003 (0.834)	0.664	0.664
	0.034 (0.086)	2.046 (0.141)	-1.283 (0.389)	**-0.832 (0.000)**	**-0.090 (0.019)**	-1.121 (0.468)	0.023 (0.591)	-0.745 (0.875)	0.668	0.664
INV_{t+1}	0.033 (0.156)	**3.955 (0.019)**	**-4.526 (0.014)**	**-0.243 (0.015)**	**-0.269 (0.000)**	-2.158 (0.243)	**0.089 (0.089)**		0.377	0.287
	0.049 (0.045)			**-0.267 (0.012)**	**-0.250 (0.000)**	**-3.448 (0.073)**	0.064 (0.245)	-5.864 (0.338)	0.286	0.286
	0.035 (0.145)	**3.955 (0.020)**	**-4.410 (0.017)**	**-0.250 (0.013)**	**-0.269 (0.000)**	-2.239 (0.228)	**0.093 (0.081)**	-4.858 (0.397)	0.374	0.286

Singapore	CON	NAM_t	NAM_{t-1}	DEP_t	EXR_t	SD_t	DY_t	GAM_t	R^2 adj	R^2 adj EX
GDP_{t+1}	0.021 (0.005)	-0.016 (0.497)	0.017 (0.470)	0.015 (0.911)	0.037 (0.364)	-0.754 (0.177)	-0.015 (0.503)		-0.014	0.007
	0.022 (0.003)			0.001 (0.994)	0.034 (0.401)	-0.815 (0.139)	-0.016 (0.456)	-0.006 (0.337)	0.006	0.006
	0.022 (0.004)	-0.013 (0.590)	0.012 (0.602)	0.013 (0.922)	0.034 (0.408)	-0.785 (0.162)	-0.014 (0.515)	-0.005 (0.420)	-0.019	0.006
UN_{t+1}	-0.049 (0.224)	-0.0004 (0.997)	-0.005 (0.969)	-0.060 (0.677)	-0.386 (0.105)	4.014 (0.231)	0.184 (0.164)		0.016	0.046
	-0.049 (0.230)			-0.054 (0.710)	-0.392 (0.099)	3.938 (0.238)	0.182 (0.164)	-0.008 (0.827)	0.032	0.032
	-0.048 (0.243)	0.004 (0.974)	-0.012 (0.929)	-0.054 (0.717)	-0.392 (0.104)	3.909 (0.251)	0.182 (0.172)	-0.009 (0.289)	0.001	0.032
$CONS_{t+1}$	0.022 (0.002)	-0.046 (0.044)	0.039 (0.083)	-0.542 (0.000)	0.086 (0.038)	-0.297 (0.576)	-0.032 (0.115)		0.239	0.211
	0.022 (0.002)			-0.535 (0.000)	0.083 (0.049)	-0.356 (0.511)	-0.036 (0.086)	-0.005 (0.402)	0.208	0.208
	0.022 (0.002)	-0.045 (0.055)	0.037 (0.116)	-0.554 (0.000)	0.085 (0.041)	-0.323 (0.547)	-0.033 (0.116)	-0.003 (0.611)	0.230	0.208
INV_{t+1}	0.035 (0.072)	0.038 (0.556)	-0.066 (0.307)	-0.245 (0.049)	0.099 (0.386)	-1.965 (0.206)	0.039 (0.492)		0.024	0.037
	0.028 (0.132)			-0.163 (0.200)	0.123 (0.270)	-1.472 (0.332)	0.042 (0.451)	0.035 (0.057)	0.076	0.076
	0.029 (0.123)	0.019 (0.769)	-0.039 (0.549)	-0.170 (0.189)	0.122 (0.282)	-1.569 (0.310)	0.042 (0.463)	0.032 (0.091)	0.052	0.076
	CON	NRO_t	NRO_{t-1}	DEP_t	EXR_t	SD_t	DY_t	GRO_t	R^2 adj	R^2 adj EX
GDP_{t+1}	0.022 (0.004)	-2.769 (0.296)	2.185 (0.406)	0.004 (0.975)	0.036 (0.373)	-0.758 (0.174)	-0.016 (0.470)		-0.006	0.007
	0.022 (0.003)			0.008 (0.948)	0.039 (0.318)	-0.791 (0.143)	-0.015 (0.466)	-4.619 (0.063)	0.045	0.045
	0.022 (0.004)	-2.491 (0.339)	1.875 (0.469)	0.012 (0.926)	0.038 (0.339)	-0.764 (0.163)	-0.014 (0.499)	-4.475 (0.074)	0.029	0.045
UN_{t+1}	-0.049 (0.224)	3.215 (0.839)	-4.037 (0.793)	-0.067 (0.653)	-0.382 (0.109)	4.023 (0.231)	0.184 (0.163)		0.017	0.046
	-0.053 (0.171)			-0.085 (0.533)	-0.398 (0.077)	4.315 (0.172)	0.186 (0.135)	35.933 (0.011)	0.124	0.124
	-0.053 (0.179)	1.537 (0.919)	-1.820 (0.902)	-0.089 (0.537)	-0.396 (0.084)	4.316 (0.181)	0.186 (0.142)	35.832 (0.013)	0.096	0.124
$CONS_{t+1}$	0.021 (0.003)	-2.165 (0.426)	2.895 (0.273)	-0.512 (0.000)	0.082 (0.052)	-0.273 (0.615)	-0.034 (0.103)		0.202	0.211
	0.022 (0.002)			-0.515 (0.000)	0.085 (0.047)	-0.319 (0.556)	-0.036 (0.089)	0.025 (0.992)	0.199	0.199
	0.021 (0.003)	-2.177 (0.417)	2.909 (0.276)	-0.514 (0.000)	0.082 (0.054)	-0.274 (0.617)	-0.034 (0.106)	0.215 (0.934)	0.189	0.199
INV_{t+1}	0.032 (0.078)	-22.603 (0.002)	12.709 (0.079)	-0.221 (0.070)	0.091 (0.389)	-1.668 (0.252)	0.047 (0.382)		0.158	0.037
	0.033 (0.086)			-0.232 (0.066)	0.100 (0.379)	-1.833 (0.236)	0.043 (0.457)	-4.244 (0.552)	0.028	0.028
	0.032 (0.083)	-22.465 (0.002)	12.633 (0.083)	-0.212 (0.088)	0.094 (0.382)	-1.649 (0.260)	0.048 (0.373)	-3.328 (0.619)	0.148	0.028

Panel B: All Markets								
	Average R^2 adj (all countries)				Proportion of R^2 adj (all countries)			
	Financial variables only	National liquidity only	Global liquidity only	All	Contributed by Financial variables only	Contributed by National liquidity only	Contributed by Global liquidity only	Contributed by all
AM→GDP	0.182	0.182	0.165	0.173	0.259	0.259	0.235	0.246
RO→GDP	0.174	0.176	0.178	0.187	0.243	0.246	0.249	0.261
AM→UNE	0.215	0.209	0.214	0.212	0.252	0.246	0.252	0.249
RO→UNE	0.215	0.205	0.235	0.227	0.244	0.233	0.266	0.257
AM→CON	0.299	0.307	0.295	0.300	0.249	0.256	0.245	0.249
RO→CON	0.299	0.299	0.299	0.299	0.250	0.250	0.249	0.249
AM→INV	0.113	0.127	0.144	0.132	0.219	0.245	0.279	0.256
RO→INV	0.135	0.183	0.191	0.206	0.188	0.256	0.267	0.288
AM→Macros (Grand Average)	0.202	0.206	0.204	0.204	0.245	0.251	0.253	0.25
RO→Macros (Grand Average)	0.206	0.216	0.226	0.229	0.231	0.246	0.258	0.264
Panel C: Developed Markets								
AM→GDP	0.083	0.095	0.075	0.084	0.247	0.280	0.223	0.249
RO→GDP	0.083	0.088	0.084	0.09	0.241	0.254	0.244	0.260
AM→UNE	0.247	0.239	0.250	0.241	0.253	0.244	0.256	0.247
RO→UNE	0.247	0.235	0.267	0.258	0.245	0.234	0.265	0.256
AM→CON	0.286	0.306	0.283	0.30	0.243	0.261	0.241	0.255
RO→CON	0.286	0.291	0.276	0.281	0.252	0.256	0.243	0.248
AM→INV	0.077	0.097	0.121	0.105	0.192	0.243	0.302	0.263
RO→INV	0.077	0.162	0.183	0.187	0.126	0.266	0.301	0.307
AM→Macros (Grand Average)	0.173	0.184	0.182	0.183	0.234	0.257	0.255	0.254
RO→Macros (Grand Average)	0.173	0.194	0.203	0.204	0.216	0.253	0.263	0.268
Panel D: Developing Markets								
AM→GDP	0.255	0.233	0.232	0.227	0.269	0.246	0.245	0.239
RO→GDP	0.239	0.233	0.259	0.264	0.239	0.234	0.260	0.265
AM→UNE	0.115	0.106	0.106	0.103	0.268	0.246	0.246	0.239
RO→UNE	0.115	0.102	0.154	0.142	0.225	0.198	0.301	0.276
AM→CON	0.288	0.286	0.282	0.277	0.254	0.252	0.249	0.245
RO→CON	0.288	0.279	0.296	0.287	0.250	0.242	0.257	0.249
AM→INV	0.137	0.132	0.153	0.142	0.243	0.234	0.272	0.252
RO→INV	0.137	0.217	0.204	0.226	0.174	0.277	0.260	0.288
AM→Macros (Grand Average)	0.199	0.189	0.193	0.187	0.258	0.244	0.253	0.244
RO→Macros (Grand Average)	0.195	0.208	0.228	0.229	0.222	0.238	0.269	0.269

The null hypotheses are i) that the liquidity variables do not Granger cause growth in the macroeconomic variables and ii) growth in macroeconomic variables does not Granger cause liquidity. Granger causality tests show that there is weak evidence of a two way causal relationship and there is no common tendency across 6 countries.

Panels A and B in Table 5.4 shows Granger causality test results between macroeconomic variables and liquidity variables (AM and RO) for all countries. This analysis is mainly interested in panel C that summarizes the findings of panels A & B. The last column in panel C shows that the percentage of rejecting the null hypothesis (H_0: LIQ does not → MACRO) is higher than the number of rejection associated with MACRO does not Granger cause LIQ (36.4% and 23.9% respectively). Comparing between 'Sum of National' and 'Sum of Global', the 'Sum of Global' achieves a higher percentage than the 'Sum of National' in terms of rejecting the null (H_0: LIQ does not → MACRO). On the other hand, when it looks at the null (H_0: MACRO does not → LIQ), it shows higher rejection rate with the 'Sum of National'. This means that macroeconomic variables are influenced by global liquidity more than national liquidity and macroeconomic variables have a greater impact on the level of national liquidity than global liquidity. The Amihud-ratio Granger causes macro indicators more often than the ROLL measure. The Amihud (NAM and GAM) rejects the null 19 times out of 96 (19.7%) while ROLL (NRO and GRO) rejects the null 16 times out of 96 (16.6%).

For the developed markets in panel D, it obtains consistent results with those in panel C. In terms of the rejection rate in the last column, LIQ Granger causes MACRO more frequently than MACRO Grange cause LIQ (33% and 26% respectively). When it looks at the null (H_0: LIQ does not → MACRO), 'Sum of Global' (GAM & GRO) has a higher rejection rate than 'Sum of National'.

However, when it looks at the rejection rate for the null (H_0: MACRO does not → LIQ), 'Sum of National' (NAM & GAM) has a higher rejection rate than 'Sum of Global'. Also, the Amihud-ratio Granger causes macro indicators more often than the ROLL measure. AM (NAM and GAM) Granger causes macro indicators 12 times out of 64 (18.7%) while RO (NRO and GRO) Granger causes macro indicators 9 times out of 64 (14%).

For the developing markets in panel E, it obtains similar results with the previous two panels. Liquidity Granger causes macro indicators more often than macro indicators Granger causes liquidity (the last column in panel E). The number of rejections (H_0: LIQ does not → MACRO) for 'Sum of Global' is higher than for 'Sum of National' (24.9% and 18.7% respectively) while the number of rejections (H_0: MACRO does not → LIQ) for 'Sum of National' is higher than for 'Sum of Global' (12.4% and 6.2% respectively). Interestingly, it shows an equal rejection rate between the Amihud ratio (NAM and GAM) and ROLL measure (NRO and GRO) in Granger causing macroeconomic variables (7 time out of 32 or 21.8%).

The results are consistent with G&G (2013). For instance, the number of times that liquidity (national and global) Granger causes macroeconomic variables is higher than macroeconomic variables Granger cause liquidity (national and global). Also, the global liquidity appears to have a greater effect on macroeconomic variables compared to national liquidity. It obtains similar findings for the developed and the developing markets groups[33].

Results from this section confirm results obtained in the previous section that liquidity predicts future macroeconomic variables and global liquidity is more

[33] Please see table A2 in the Appendix. This study examines the causal relationship between liquidity variables and macroeconomic variables with the Dumitrescu and Hurlin (2012) causality test. The result of the test shows qualitatively similar.

important factor than national liquidity. Macroeconomic variables have a greater impact on the level of national liquidity than global liquidity in the 6 Asian markets. It means that the selected Asian markets are more sensitive to the exogenous liquidity risk than the endogenous liquidity risk. Also, the economic development of these Asian countries has an impact on its own market but it does not influence on the global liquidity level. However, the ROLL measure outperforms the Amihud ratio in section 5.3.1 (in sample test) while the Amihud ratio outperforms the ROLL measure in section 5.3.1.1 (causality test).

Table 5.4
Granger Causality Tests for ALL Countries

The table shows Granger causality tests between quarterly macroeconomic variables (GDP, INV, CONS and UN) and all liquidity variables. The prefix 'N' means national and the prefix 'G' means global. The cross sectional liquidity measures are calculated as equally weighted averages across stocks. The test is performed for the whole sample period and different subperiods even though results for subperiods are not reported here to keep the table as small as possible. We first test the null hypothesis that our liquidity variable does not Granger cause the macroeconomic variable in question and then we test the null hypothesis that our macroeconomic variable does not Granger cause the liquidity variable in question. We do this for all macroeconomic and liquidity variables. We report the χ^2 and p value (in parenthesis) for each test. We choose the optimal lag length for each test based on the Schwartz criterion. The panel C, D, and E summarizes all results obtained from panel A and B.

Panel A: National Liquidity

		AMIHUD RATIO						ROLL ESTIMATOR					
		HK (NAM)	KO (NAM)	AU (NAM)	MA (NAM)	PH (NAM)	SI (NAM)	HK (NRO)	KO (NRO)	AU (NRO)	MA (NRO)	PH (NRO)	SI (NRO)
GDP	H_0: LIQ does not → GDP	**5.531** **(0.063)**	3.925 (0.140)	1.949 (0.377)	4.146 (0.126)	**8.285** **(0.016)**	1.058 (0.589)	1.594 (0.451)	3.541 (0.170)	1.279 (0.527)	0.574 (0.750)	2.176 (0.257)	0.407 (0.816)
	H_0: GDP does not → LIQ	1.999 (0.368)	3.737 (0.154)	**5.619** **(0.072)**	0.621 (0.733)	0.387 (0.824)	0.046 (0.977)	1.918 (0.383)	**6.204** **(0.044)**	**5.039** **(0.080)**	**8.342** **(0.015)**	0.831 (0.659)	0.404 (0.817)
UN	H_0: LIQ does not → UN	4.039 (0.133)	0.514 (0.773)	3.708 (0.156)	0.429 (0.807)	1.182 (0.554)	0.004 (0.998)	0.156 (0.925)	2.421 (0.298)	0.719 (0.697)	2.436 (0.296)	1.091 (0.579)	0.289 (0.865)
	H_0: UN does not → LIQ	1.563 (0.458)	**8.535** **(0.014)**	**5.267** **(0.072)**	0.556 (0.757)	0.314 (0.855)	1.505 (0.471)	**11.115** **(0.004)**	0.268 (0.875)	3.802 (0.149)	**7.557** **(0.023)**	0.644 (0.725)	4.358 (0.113)
CONS	H_0: LIQ does not → CONS	**8.068** **(0.018)**	4.532 (0.103)	1.735 (0.42)	**5.752** **(0.056)**	**9.570** **(0.008)**	**6.696** **(0.035)**	0.618 (0.734)	0.681 (0.711)	0.874 (0.646)	0.242 (0.886)	0.757 (0.685)	1.804 (0.406)
	H_0: CONS does not → LIQ	1.350 (0.509)	**31.174** **(0.000)**	**4.940** **(0.085)**	0.987 (0.610)	1.495 (0.473)	**4.758** **(0.093)**	2.552 (0.279)	1.864 (0.394)	2.304 (0.316)	0.819 (0.664)	0.843 (0.656)	3.403 (0.182)
INV	H_0: LIQ does not → INV	1.884 (0.389)	1.122 (0.570)	1.564 (0.457)	**4.766** **(0.092)**	**6.818** **(0.033)**	1.792 (0.408)	1.534 (0.464)	1.167 (0.558)	**6.679** **(0.035)**	1.519 (0.468)	**7.845** **(0.019)**	**13.643** **(0.001)**
	H_0: INV does not → LIQ	1.371 (0.504)	2.340 (0.310)	1.529 (0.655)	**5.599** **(0.061)**	**7.653** **(0.021)**	**8.118** **(0.017)**	2.586 (0.274)	1.676 (0.433)	0.099 (0.549)	3.100 (0.212)	2.561 (0.278)	1.092 (0.579)

Panel B: Global liquidity

		AMIHUD RATIO						ROLL ESTIMATOR					
		HK (GAM)	KO (GAM)	AU (GAM)	MA (GAM)	PH (GAM)	SI (GAM)	HK (GRO)	KO (GRO)	AU (GRO)	MA (GRO)	PH (GRO)	SI (GRO)
GDP	H_0: LIQ does not → GDP	**4.986 (0.083)**	**6.493 (0.039)**	1.217 (0.544)	2.508 (0.285)	1.441 (0.487)	**9.074 (0.011)**	**5.791 (0.055)**	1.553 (0.459)	0.102 (0.950)	2.281 (0.319)	**11.801 (0.003)**	1.528 (0.466)
	H_0: GDP does not → LIQ	2.816 (0.244)	1.461 (0.481)	2.041 (0.360)	3.429 (0.181)	1.000 (0.606)	**5.660 (0.059)**	1.994 (0.369)	0.354 (0.838)	4.561 (0.102)	1.320 (0.517)	0.116 (0.943)	0.804 (0.669)
UN	H_0: LIQ does not → UN	**6.454 (0.039)**	**10.714 (0.005)**	2.593 (0.273)	1.181 (0.554)	0.367 (0.832)	2.193 (0.334)	**6.344 (0.042)**	**8.644 (0.013)**	2.126 (0.345)	**4.718 (0.094)**	**8.440 (0.015)**	**17.229 (0.000)**
	H_0: UN does not → LIQ	2.488 (0.288)	**5.653 (0.059)**	0.048 (0.976)	**5.473 (0.065)**	1.132 (0.568)	1.742 (0.418)	0.162 (0.922)	**6.271 (0.043)**	2.611 (0.271)	2.973 (0.226)	3.846 (0.146)	0.299 (0.861)
CONS	H_0: LIQ does not → CONS	**6.905 (0.032)**	**11.451 (0.003)**	1.848 (0.397)	**14.322 (0.001)**	1.037 (0.595)	**7.339 (0.025)**	**6.999 (0.030)**	**7.376 (0.025)**	0.279 (0.869)	**21.002 (0.000)**	**7.210 (0.027)**	0.719 (0.697)
	H_0: CONS does not → LIQ	0.413 (0.813)	**9.267 (0.009)**	3.214 (0.201)	4.189 (0.123)	0.665 (0.717)	1.381 (0.501)	**5.517 (0.063)**	0.764 (0.682)	2.444 (0.295)	2.150 (0.341)	0.363 (0.834)	0.963 (0.618)
INV	H_0: LIQ does not → INV	0.631 (0.729)	**10.628 (0.005)**	1.220 (0.543)	**5.768 (0.056)**	1.273 (0.529)	2.618 (0.270)	0.264 (0.876)	0.742 (0.690)	**10.753 (0.005)**	1.979 (0.372)	**8.873 (0.012)**	1.205 (0.547)
	H_0: INV does not → LIQ	4.270 (0.118)	**7.646 (0.022)**	0.823 (0.289)	0.973 (0.615)	2.674 (0.263)	4.217 (0.121)	0.371 (0.603)	**5.524 (0.063)**	2.576 (0.276)	0.432 (0.806)	**7.541 (0.023)**	1.969 (0.373)

Panel C: Summary table (All markets)							
	NAM	NRO	Sum of National (NAM &NRO)	GAM	GRO	Sum of Global (GAM&GRO)	ALL Liquidity
H_0: LIQ does not → MACRO	8 out of 96 (8.3%)	3 out of 96 (3.1%)	11.4%	11 out of 96 (11.4%)	13 out of 96 (13.5%)	24.9%	35 out of 96 (36.4%)
H_0: MACRO does not → LIQ	9 out of 96 (9.4%)	5 out of 96 (5.2%)	14.6%	5 out of 96 (5.2%)	4 out of 96 (4.2%)	9.4%	23 out of 96 (23.9%)

Panel D: Summary table (Developed Markets)							
	NAM	NRO	Sum of National (NAM & NRO)	GAM	GRO	Sum of Global (GAM & GRO)	ALL Liquidity
H_0: LIQ does not → MACRO	3 out of 64 (4.7%)	2 out of 64 (3.1%)	7.8%	9 out of 64 (14.1%)	7 out of 64 (10.9%)	15%	21 out of 64 (32.8%)
H_0: MACRO does not → LIQ	7 out of 64 (10.9%)	3 out of 64 (4.7%)	15.6%	4 out of 64 (6.2%)	3 out of 64 (4.7%)	10.9%	17 out of 64 (26.5%)

Panel E: Summary table (Developing Markets)							
	NAM	NRO	Sum of National (NAM & NRO)	GAM	GRO	Sum of Global (GAM & GRO)	ALL Liquidity
H_0: LIQ does not → MACRO	5 out of 32 (15.6%)	1 out of 32 (3.1%)	18.7%	2 out of 32 (6.2%)	6 out of 32 (18.7%)	24.9%	14 out of 32 (43.7%)
H_0: MACRO does not → LIQ	2 out of 32 (6.2%)	2 out of 32 (6.2%)	12.4%	1 out of 32 (3.1%)	1 out of 32 (3.1%)	6.2%	6 out of 32 (18.7%)

5.3.2 OUT-OF-SAMPLE EVIDENCE

The previous section examined the predictive power of liquidity variables for certain macroeconomic variables while controlling for financial variables such as volatility, excess market returns, and dividend yields for 6 Asian markets. It showed that the relation between liquidity and macroeconomic variables is varying by country which is consistent with the main finding of G&G (2013). This section performs out-of-sample tests to further investigate if the national liquidity variables which survived the previous in sample tests can predict the macroeconomic indicators. Since the out-of-sample forecasting performance depends on how a given data set is split into estimation and evaluation period, it is important to use as large sample as possible to achieve a robust and consistent result for forecasting out-of-sample period. If the forecasting model has various splitting points as the rolling technique, the large size of distortion can occur for the rejection rates of prediction accuracy. Therefore, this study follows G&G (2013). The sample splits in half and use the first half to predict the second half of the sample for all countries. It estimates two forecasting models and each model has two specifications namely restricted and unrestricted. In the first forecasting model, the unrestricted specification contains national liquidity and financial variables and global liquidity while the restricted specification contains only financial variables and global liquidity. In the second forecasting model, an unrestricted model contains national and global liquidity, financial variables and an autoregressive term of the macro variable. The restricted specification includes an autoregressive term of the macro variable only.

To evaluate their forecasting performance, it uses three statistical tests such as the ratio of mean squared errors (MSE), MSE-F test (McCracken, 2007), and ENC-

NEW test (Clark and McCracken, 2001). Firstly, the MSE ratio is calculated by dividing the MSE of the unrestricted model by the MSE of the restricted model ($\mathrm{MSE_U/MSE_R}$). The ratio of $\mathrm{MSE_U/MSE_R}$ shows which model's mean squared errors are greater. If the ratio is equal to 1, then this implies that the mean squared errors are equal between the unrestricted and restricted model. If the ratio is greater than 1, it means that the MSE of the unrestricted model are bigger. The second test is MSE-F. The test for equality between MSEs from the two competing forecasting models is obtained by the following formula.

$$\mathrm{MSE-F} = \left[\mathrm{P}^{-1}\sum_{\mathrm{t=R}}^{\mathrm{T}}(\varepsilon_{\mathrm{r,t+1}}^2 - \varepsilon_{\mathrm{u,t+1}}^2)/\mathrm{P}^{-1}\sum_{\mathrm{t=R}}^{\mathrm{T}}(\varepsilon_{\mathrm{u,t+1}}^2)\right] \tag{5.3}$$

Where $\varepsilon_{\mathrm{r,t+1}}^2$ are the squared errors from the restricted model and $\varepsilon_{\mathrm{u,t+1}}^2$ are the squared errors from the unrestricted model, P is the number of forecasts. The final test for evaluating performance is ENC-NEW test. The ENC-NEW test statistic is given by:

$$\mathrm{ENC-NEW} = \mathrm{P}\left[\mathrm{P}^{-1}\sum_{\mathrm{t}}(\varepsilon_{\mathrm{r,t+1}}^2 - \varepsilon_{\mathrm{r,t+1}} * \varepsilon_{\mathrm{u,t+1}}/\mathrm{P}^{-1}\sum_{\mathrm{t}}(\varepsilon_{\mathrm{u,t+1}}^2)\right] \tag{5.4}$$

Where P is the number of forecasts, $\varepsilon_{\mathrm{r,t+1}}^2$ are the squared errors of the restricted model and $\varepsilon_{\mathrm{r,t+1}}$ is the out of sample errors from the restricted model and $\varepsilon_{\mathrm{u,t+1}}$ is the out of sample errors of the unrestricted model. $\varepsilon_{\mathrm{u,t+1}}^2$ is the squared errors of the unrestricted model.

The Null hypothesis of MSE-F is: $\mathrm{MSE_r = MSE_u}$. The null of ENC-NEW is: 'R encompasses U'. In other words, the null of MSE-F is the restricted model which excludes liquidity, has a mean-squared forecasting error that equals the mean squared forecasting error of the unrestricted model that includes liquidity; the alternative is that mean-squared errors of the unrestricted model is not equal to mean-squared errors of the restricted model. For the ENC-NEW test, the null hypothesis states that the restricted model's forecast "encompasses" all relevant information for next period's value of the dependent variable, against the alternative that the unrestricted model which includes national liquidity contains additional information. Table 5.5 presents results for the two forecasting models. Each panel is dedicated to a specific country. Firstly, it reports results from "national illiquidity versus control variables" and then will discuss results from "Autoregressive model" for the 6 countries.

Generally, results show that national liquidity has some forecasting ability over financial variables and global liquidity. For Korea (see panel B), RO has extra forecasting power for GDP (see C6, MSE-F rejects the H_0) and for CONS (see C6 and C7, both MSE-F and ENC-NEW reject the H_0). For Singapore (panel F), RO has forecasting ability for CONS only over the financial variables and global liquidity (see C6). It does not have any evidence that national liquidity variables have some forecasting ability over financial variables and global liquidity for the other countries.

The result from the autoregressive model shows that the null hypothesis is rejected for Hong Kong and Philippines only. For Hong Kong (panel A), AM has extra forecasting power for GDP and UN. Both MSE-F and ENC-NEW reject the null hypothesis that the restricted model encompasses the unrestricted model (see C6 and C7). In the case of Philippines (panel E), when predicting INV, ENC-NEW reject the null (see C7).

Overall, national liquidity variables have some forecasting ability over financial variables and global liquidity for Hong Kong, Korea and Philippines. However, it does not obtain any evidence of forecasting ability for the rest of the countries in the out-of-sample test. It means that these countries have a persistent risk captured by national liquidity over the sample period.

Table 5.5
Result of Out of Sample Tests

Table 5.5 shows predictability of macroeconomic growth by looking at the out of sample test. The table also presents results for 'Illiquidity variables versus Control variables' and 'Autoregressive models'. We compare unrestricted model and restricted model. Our illiquidity variables are NAM and NRO and our control variables are our financial variables (FV) and global AM (GAM) or RO (GRO). MSE-F and ENC NEW are the two tests we use to draw conclusions. MSE-F tests for MSE equality between restricted and unrestricted models (H_0: $MSE_r=MSE_u$) while ENC-NEW tests whether the restricted model encompasses the unrestricted model (H_0: R encompasses UN). We also present results for MSE_u/MSE_r, where the subscripts u and r stand for unrestricted and restricted. Model comparisons are undertaken for illiquidity variables (NAM and NRO) which survived the in-sample regressions of the previous section. *,**,*** indicates statistically significant at 10%, 5%, and 1% respectively.

Panel A: Hong Kong						
NATIONAL ILLIQUIDITY VS CONTROL VARIABLES						
C1	C2	C3	C4	C5	C6	C7
		UNRESTRICTED	RESTRICTED	MSE_U/MSE_R	MSE-F	ENC-NEW
GDP	AM	AM + FIN VAR + Global L	FIN VAR + Global L	0.983	0.595	0.451
CONS	AM	AM + FIN VAR + Global L	FIN VAR + Global L	1.002	-0.056	0.001
UN	AM	AM + FIN VAR + Global L	FIN VAR + Global L	0.999	0.049	0.025
AUTOREGRESSIVE MODEL						
		UNRESTRICTED	RESTRICTED	MSE_U/MSE_R	MSE-F	ENC-NEW
GDP	AM	AR(1) + AM + FIN VAR + Global L	AR(1)	0.690	15.70***	10.75***
CONS	AM	AR(1) + AM + FIN VAR + Global L	AR(1)	1.103	-3.283	-0.906
UN	AM	AR(1) + AM + FIN VAR + Global L	AR(1)	0.918	3.129**	5.792**

Panel B: Korea						
NATIONAL ILLIQUIDITY VS CONTROL VARIABLES						
C1	C2	C3	C4	C5	C6	C7
		UNRESTRICTED	RESTRICTED	MSE_U/MSE_R	MSE-F	ENC-NEW
GDP	RO	RO + FIN VAR + Global L	FIN VAR + Global L	0.943	2.094*	1.092
CONS	RO	RO + FIN VAR + Global L	FIN VAR + Global L	0.849	6.219***	3.604**
AUTOREGRESSIVE MODEL						
		UNRESTRICTED	RESTRICTED	MSE_U/MSE_R	MSE-F	ENC-NEW
GDP	RO	AR(1) + RO + FIN VAR + Global L	AR(1)	1.315	-8.395	-0.256
CONS	RO	AR(1) + RO + FIN VAR + Global L	AR(1)	1.611	-13.28*	-2.345

Panel C: Australia						
NATIONAL ILLIQUIDITY VS CONTROL VARIABLES						
C1	C2	C3	C4	C5	C6	C7
		UNRESTRICTED	RESTRICTED	MSE_U/MSE_R	MSE-F	ENC-NEW
INV	RO	RO + FIN VAR + Global L	FIN VAR + Global L	1.006	-0.199	0.485
AUTOREGRESSIVE MODEL						
		UNRESTRICTED	RESTRICTED	MSE_U/MSE_R	MSE-F	ENC-NEW
INV	RO	AR(1) + RO + FIN VAR + Global L	AR(1)	1.226	-6.454	3.971*

Panel D: Malaysia						
NATIONAL ILLIQUIDITY VS CONTROL VARIABLES						
C1	C2	C3	C4	C5	C6	C7
		UNRESTRICTED	RESTRICTED	MSE_U/MSE_R	MSE-F	ENC-NEW
GDP	AM	AM + FIN VAR + Global L	FIN VAR + Global L	1.048	-1.605	-0.072
AUTOREGRESSIVE MODEL						
		UNRESTRICTED	R	MSE_U/MSE_R	MSE-F	ENC-NEW
GDP	AM	AR(1) + AM + FIN VAR + Global L	AR(1)	1.166	-4.987	1.753

Panel E: Philippines						
NATIONAL ILLIQUIDITY VS CONTROL VARIABLES						
C1	C2	C3	C4	C5	C6	C7
		UNRESTRICTED	RESTRICTED	MSE_U/MSE_R	MSE-F	ENC-NEW
GDP	RO	RO + FIN VAR + Global L	FIN VAR + Global L	0.999	0.019	0.012
INV	RO	RO + FIN VAR + Global L	FIN VAR + Global L	0.984	0.558	0.328
AUTOREGRESSIVE MODEL						
		UNRESTRICTED	RESTRICTED	MSE_U/MSE_R	MSE-F	ENC-NEW
GDP	RO	AR(1) + RO + FIN VAR + Global L	AR(1)	1.708	-14.51*	-5.233
INV	RO	AR(1) + RO + FIN VAR + Global L	AR(1)	1.271	-7.463	6.912***

Panel F: Singapore						
NATIONAL ILLIQUIDITY VS CONTROL VARIABLES						
C1	C2	C3	C4	C5	C6	C7
		UNRESTRICTED	RESTRICTED	MSE_U/MSE_R	MSE-F	ENC-NEW
CONS	AM	AM + FIN VAR + Global L	FIN VAR + Global L	0.996	0.138	0.229
	RO	RO + FIN VAR + Global L	FIN VAR + Global L	0.935	2.447**	1.578
AUTOREGRESSIVE MODEL						
		UNRESTRICTED	RESTRICTED	MSE_U/MSE_R	MSE-F	ENC-NEW
CONS	AM	AR(1) + AM + FIN VAR + Global L	AR(1)	1.068	-2.219	-0.761
	RO	AR(1) + RO + FIN VAR + Global L	AR(1)	1.266	-7.361	-1.837

5.4. FIRM SIZE AND THE INFORMATION CONTENT OF LIQUIDITY

NSO (2011) find that the liquidity of small firms is more informative than large firms' liquidity for forecasting future macro variables while G&G (2013) present opposite findings. This discrepancy between NSO (2011) and G&G (2013) could depend on market characteristics. Thus, this section investigates Asian-Pacific economies because it differs to the US and major European economies such as the trading mechanism, the types of investors, market efficiency in general, and the strength of regulations. The model creates two sizes of portfolios namely small and large. It assigns stocks into quintiles based on their market capitalization on the last trading day of the previous year. Small liquidity is the respective illiquidity proxy sampled for the 20% of smallest firms and large liquidity is the respective illiquidity proxy sampled for the 20% largest firms. Global large and Global small liquidity is created by averaging all countries small liquidity and large liquidity (including the US and Japan) excluding the country nominated for the test each time. The suffix S and L at the end of each variable's name stands for Small and Large respectively, for instance, National AM Small (NAMS) and National RO Large (NROL). Similarly, Global AM Small (Global RO Large) is denoted as GAMS (GROL).

Table 5.6 presents results for the in sample predictability of small and large firms' liquidity. Panel A presents results for individual countries while it summarizes individual results in panel B. In general, financial variables are important in explaining macroeconomic variables especially volatility and dividend yield and there is no such a common behavioural pattern of liquidity variables across the 6 markets. The regression results in panel B indicate that neither small (national & global) nor large (national & global) firms' liquidity appear to have any extra explanatory power over financial variables. R^2 adj. is lower or remains the same compared to R^2 adj obtained when regressing macro variables on financial variables only. However when it contrasts between large firm liquidity (national & global) and small firm liquidity (national & global), it shows that large firm liquidity (national & global) appears to have grater explanatory power compared to small firm liquidity (national & global). This is particularly pronounced when liquidity is captured by RO. The R^2adj obtained by regressing macroeconomic variables on small firm liquidity (national & global) is 0.22 while R^2adj increases to 0.25, when it regress macroeconomic variables on large firm liquidity (national & global).

As before, the study regroups the 6 countries in developed and developing markets, results are presented in panels C and D. For the developed markets group, it has similar results as in panel B. The liquidity variables (national & global) do not have extra explanatory power over financial variables. For the developing markets group, only AM has extra explanatory power and large firms' liquidity (both national and global) contains more information for macroeconomic variables than small firms' liquidity. For instance, NAML and NAML & GAML increase R^2adj by 4% while NAMS and NAMS & GAMS increase R^2adj by 3%.

Table 5.7 (Panel A) reports results of Granger causality regressions for individual countries. Contrary to NSO (2011), the study finds a weak two way relationship between macroeconomic variables and liquidity variables. Liquidity (small and large) Granger cause macroeconomic indicators 49 times out of 192 (25.5%)

while macroeconomic indicators Granger cause liquidity (small and large) 42 times out of 192 (21.8%).

Again, the study creates a summary table for all markets (panel B). The number of times that small firms liquidity (both national and global) rejects the null hypothesis (H_0: liquidity does not Granger cause macroeconomic indicators) is 13 out of 96 (13.5%) while the number of times that large firms liquidity rejects the null is 36 times out of 96 (37.5%). Thus, large firms' liquidity Granger causes macro indicators more often than small firms' liquidity and the ROLL liquidity measure always scores the highest percentages in rejection of the H_0. When the analysis concentrates on the effect of national and global liquidity, it shows that the number of rejections (H_0: Global liquidity does not → MACRO) for Global liquidity is always higher than National liquidity. This means that Global liquidity Granger causes macro indicators more often than national liquidity.

Panel C and D present results for developed and developing markets respectively. For the developed markets group (panel C), large firms' liquidity has a higher rejection rate of the null (H_0: liquidity does not → MACRO) than small firms' liquidity (39% and 14% respectively). Thus, large firm's liquidity Granger causes macro indicators more often than small firms' liquidity. Global liquidity rejects the null (H_0: liquidity does not → MACRO) more frequently than national liquidity rejects the null. Also, RO outperforms AM in the number of times that the null (H_0: liquidity does not → MACRO) is rejected. For developing markets group, the test obtains similar results as before. Large firms' liquidity Granger causes macro variables more often than small firms' liquidity and Global liquidity

Granger causes macroeconomic indicators more often than national liquidity. Finally RO always scores higher rejection rate than AM.

Panels E, F, and G present results associated with the null hypothesis (H_0: MACRO → liquidity). In panel E (all markets) shows that macro indicators Granger cause small firm's liquidity more often than macro indicators Granger cause large firm's liquidity. Also it has a higher rejection rate of the null for national liquidity than global liquidity. This implies that macro indicators have a greater impact on national small firms' liquidity than national large firms' liquidity. For developed markets (panel F), the test obtains similar results as in panel E. Macro indicators Granger cause small firms' liquidity more often than macro indicators Granger cause large firms' liquidity. Also, it shows higher rejection rate for national liquidity. However, when it looks at the developing markets group (panel G), it finds that changes in macroeconomic variables have a stronger impact on large national firms' liquidity rather than on small.

From table 5.6 through 5.7, large firms' liquidity appears to have a stronger effect on macroeconomic indicators compared to the liquidity of smaller firms in the 6 Asian markets. This is consistent with G&G (2013). However, contrary to G&G (2013), this study finds that global liquidity is more important factor in the 6 Asian countries. G&G (2011) find that national liquidity is more important than global liquidity in G7 countries. This inconsistent result confirms that the sensitivity of market against risks is varying by country. For instance, selected Asian countries are more sensitive to the external shocks than internal shocks while G7 economies show that its own liquidity risk is more important than the external liquidity risk. When it regroups the 6 Asian countries as developed markets and developing markets, it obtains similar results. Given the results and results by G&G (2013), the study can safely conclude that large firm liquidity has a greater impact on macroeconomic variables. Additionally, changes in macroeconomic variables have a stronger impact on small national firms' liquidity for developed markets while changes in macroeconomic variables have a stronger impact on large national firms' liquidity for developing markets.

5.5. CONCLUSION

This is the first empirical study investigating the effect of stock market liquidity (National and Global) on macroeconomic variables such as GDP, Unemployment, Consumption, and Investment for developed and developing Asia-Pacific economics such as Australia, Hong Kong, Korea, Philippines, Singapore and Malaysia. This paper shows similar results with G&G (2013). For example, some of the liquidity variables are able to predict macroeconomic variables even after controlling for financial variables but these variables are not consistent over 6 countries. This inconsistent result could stem from the fact that a country has the priory sector which creates the biggest contribution to the economic growth and it differs to each country. This different preference in an economy could create different market characteristics such as the economic structure, the trading mechanism, the type of investors, and the strength of regulations. Thus, the market reaction to the risk must be different for each country and these country specifications are reflected in the inconsistent result over countries.

Another interesting finding is that the ROLL measure outperforms the Amihud ratio in predicting macroeconomic variables in most cases. The ROLL measure can capture the effect of temporary shortage in liquidity while the Amihud cannot distinguish between the temporary lack of liquidity and the permanent price effect. Thus, it suggests that the empirical study could have a weak or a wrong result that depends on which liquidity proxy is used in the study. Also the contribution made by global liquidity on the regression model is always higher than the contribution made by national liquidity in the 6 Asian markets. This study also regroup the 6 countries as developed markets (Australia, Hong Kong, Korea and Singapore) and developing markets (Philippines and Malaysia) following the FTSE country classification and obtain similar results. From the Granger causality tests, it finds that liquidity Granger causes macroeconomic variables more frequently than macroeconomic variables Granger cause liquidity. Also, global liquidity has a stronger impact on macroeconomic variables than national liquidity while macroeconomic variables have a stronger impact on national liquidity than global liquidity. This applies to both groups of developed and developing markets. The evidence implies that the economic performance in these selected Asian countries is influenced by external liquidity risks more than by internal liquidity risks and the externally influenced macroeconomic variables have an impact on the national liquidity level. It clearly shows the channel through which the global liquidity risk can spread to the Asian countries.

This study investigates the relationship between liquidity and macroeconomic indicators with different size of portfolios (small and large). It shows that large firms' liquidity appears to have a stronger effect on macroeconomic variables compared to the liquidity of smaller firms in the 6 Asian countries. This is consistent with G&G (2013). However, contrary to G&G (2013), the study finds that global liquidity is a more important factor in the 6 Asian countries. In other words, selected Asian countries are more sensitive to the external shocks than internal shocks while G7 economies show that its own liquidity risk is more important than the external liquidity risk. Additionally, changes in macroeconomic variables have a strong impact on small national firms' liquidity for developed markets while changes in macroeconomic variables have a stronger impact on large national firms' liquidity for developing markets.

Evidence from this study and G&G (2013) show that there is a two way relationship between liquidity variables and macroeconomic indicators. Liquidity variables have some ability to predict macroeconomic indicators but this is country and variable specific. In addition large firm liquidity has greater predictive ability compared to small firm liquidity for developing market contrary to NSO findings (2011). This suggests that the correlation between large firms' liquidity and the economic condition is higher than correlation between small firms' liquidity and the economic condition for developing markets. In terms of reaction to the risk, large firms' liquidity should be less sensitive to the changes in macroeconomic variables than small firms' liquidity because large firms are more liquid and robust against risks in general. However, it does not hold for developing Asian markets and the possible explanation could be the large firm-biased market structure.

Table 5.6

Preceding Macro Variables with Market Liquidity – Size Portfolios

Table 5.6 present results of the multivariate OLS model which regressing macro variables at time t+1 (GDP, UN, CONS, and INV) on current (at time t) and lagged (at time t+1) market illiquidity of small (AMS and ROS) and large (AML and ROL) firms, Global illiquidity, and control variables (SD, EXR, and DY). Market illiquidity (LIQ) is captured by the Amihud ratio (AM) and Roll's effective spread (RO). The estimated model is $Y_{t+1}=\alpha + \beta_{s,t}LIQ_t^S+\beta_{s,t-1}LIQ^S_{t-1}+\beta_{L,t}LIQ_t^L+\beta_{L,t-1}LIQ^L_{t-1}+ \beta_{s,t}GLIQ_t^S + \beta_{L,t}GLIQ_t^L + \gamma' X_t+u_{t+1}$, where Y_{t+1} is GDP, CONS, INV and UN growth, LIQ_t^S is the respective illiquidity proxy sampled for the 20% smallest firms and LIQ_t^L is the illiquidity of the 20% largest firms, LIQ^S_{t-1} is the first lag of the 20% smallest firms, LIQ^L_{t-1} is the first lag of the 20% largest firms, X_t contains the additional control variables (EXR, SD, and DY) and γ' is the vector of the coefficients estimates for the control variables. Global liquidity is created by combining all countries (The US and Japan are included) except the country nominated for the test. The first of the last six columns reports adjusted R^2 of Full Variable and the second of the last six columns R^2 adj SN reports R^2 adj excluding small local liquidity variables, R^2 adj SN & SG reports R^2 adj excluding small local liquidity and small global liquidity. The fourth of the last six columns reports adjusted R^2 excluded large small local liquidity and R^2 adj LN & LG reports adjusted R^2 excluding large local and large global liquidity. The last column shows adjusted R^2 from the model including control variables only. The prefix 'O' and 'd' in front of variables means that the variable has been orthogonalized and differenced to become stationary respectively. P-value is in parenthesis.

Panel A: Results of regression for each country

Australia	CON	NAMS (OAMS)	NAMS -1 (OAMS -1)	NAML (OdAML)	NAML -1 (OdAML -1)	DDEP	OEXR	dSD	dDY	GLOBS (OGSAM)	GLOBL (OGLAM)	R^2adj ALL	R^2adj SN	R^2adj SN & SG	R^2adj LN	R^2adj LN & LG	R^2adj FV
GDP_{t+1}	**0.008** **(0.000)**	-9.2E-06 (0.702)	-1.3E-05 (0.591)	-0.001 (0.689)	0.001 (0.580)	-0.166 (0.253)	0.863 (0.209)	-0.0002 (0.850)	-0.002 (0.829)	0.019 (0.401)	1.315 (0.469)	-0.072	-0.033	-0.034	-0.031	-0.043	-0.005
UN_{t+1}	**-0.010** **(0.011)**	-0.0001 (0.301)	1.8E-06 (0.989)	0.0002 (0.974)	-0.007 (0.452)	-0.076 (0.571)	**-21.29** **(0.000)**	0.0003 (0.943)	0.082 (0.122)	-0.163 (0.194)	**25.98** **(0.015)**	0.382	0.338	0.342	0.336	0.341	0.349
$CONS_{t+1}$	**0.009** **(0.000)**	**5.02E-05** **(0.014)**	-1.65E-05 (0.437)	0.001 (0.324)	0.001 (0.665)	0.214 (0.129)	**1.126** **(0.078)**	**-0.001** **(0.041)**	-0.005 (0.523)	0.008 (0.682)	-0.714 (0.685)	0.119	0.158	0.148	0.068	0.053	0.081
INV_{t+1}	**0.018** **(0.000)**	-4.4E-05 (0.819)	-2.7E-05 (0.884)	-0.009 (0.506)	-0.014 (0.258)	**-0.431** **(0.002)**	-1.152 (0.811)	0.011 (0.158)	-0.009 (0.883)	-0.131 (0.438)	-9.423 (0.454)	0.107	0.097	0.105	0.136	0.141	0.110
Dependent	CON	NROS (OROS)	NROS -1 (OROS -1)	NROL (OROL)	NROL -1 (OROL -1)	DDEP	OEXR	dSD	dDY	GLOBS (OGSRO)	GLOBL (OGLRO)	R^2adj ALL	R^2adj SN	R^2adj SN & SG	R^2adj LN	R^2adj LN & LG	R^2adj FV
GDP_{t+1}	**0.008** **(0.000)**	0.252 (0.169)	-0.191 (0.281)	**-1.075** **(0.029)**	-0.215 (0.671)	**-0.285** **(0.043)**	0.953 (0.113)	-0.002 (0.790)	-0.0003 (0.970)	-0.386 (0.536)	0.146 (0.671)	0.064	-0.006	-0.023	0.085	0.071	-0.005
UN_{t+1}	**-0.009** **(0.020)**	-0.941 (0.405)	-0.619 (0.575)	1.092 (0.712)	1.549 (0.621)	-0.109 (0.417)	**-21.87** **(0.000)**	0.0004 (0.940)	0.077 (0.161)	2.726 (0.507)	-0.231 (0.925)	0.307	0.343	0.334	0.332	0.320	0.389
$CONS_{t+1}$	**0.009** **(0.000)**	0.247 (0.152)	0.132 (0.428)	-0.179 (0.699)	-0.524 (0.260)	0.137 (0.361)	0.961 (0.131)	-0.001 (0.266)	-0.003 (0.738)	0.391 (0.528)	-0.287 (0.505)	0.075	0.086	0.084	0.082	0.069	0.081
INV_{t+1}	**0.019** **(0.000)**	-0.105 (0.940)	0.365 (0.791)	-6.174 (0.108)	-0.043 (0.991)	**-0.482** **(0.000)**	1.104 (0.796)	0.008 (0.226)	0.014 (0.821)	-4.200 (0.370)	**-5.349** **(0.031)**	0.205	0.147	0.234	0.147	0.234	0.110

Hong Kong	CON	NAMS (OAMS)	NAMS -1 (OAMS -1)	NAML (dAML)	NAML -1 (dAML -1)	DDEP	EXR	SD	DY	GAMS (OGSAM)	GAML (OGLAM)	R^2adj ALL	R^2adj SN	R^2adj SN & SG	R^2adj LN	R^2adj LN & LG	R^2adj FV
GDP_{t+1}	0.007 (0.819)	-9.359 (0.417)	2.352 (0.508)	0.003 (0.869)	-0.016 (0.293)	-0.003 (0.984)	-0.088 (0.359)	**-1.939 (0.065)**	0.008 (0.432)	-0.001 (0.471)	**-45.909 (0.011)**	0.074	-0.011	-0.017	0.012	0.010	0.021
UN_{t+1}	-0.118 (0.103)	-17.79 (0.227)	6.818 (0.249)	0.001 (0.979)	-0.014 (0.538)	**0.397 (0.004)**	-0.154 (0.156)	**7.441 (0.000)**	0.002 (0.942)	9.9E-05 (0.960)	19.55 (0.488)	0.504	0.530	0.522	0.459	0.461	0.469
$CONS_{t+1}$	0.007 (0.589)	**-5.254 (0.074)**	3.303 (0.107)	0.0003 (0.969)	-0.009 (0.265)	**-0.755 (0.000)**	-0.014 (0.602)	**-1.325 (0.001)**	0.006 (0.134)	-0.001 (0.144)	**-17.803 (0.013)**	0.568	0.510	0.524	0.505	0.542	0.506
INV_{t+1}	0.034 (0.235)	9.014 (0.346)	-5.184 (0.306)	0.003 (0.850)	-0.014 (0.434)	**-0.387 (0.003)**	0.041 (0.615)	-1.412 (0.123)	-0.003 (0.758)	-0.002 (0.183)	-23.27 (0.158)	0.080	0.059	0.080	0.050	0.089	0.069
Dependent	CON	NROS (OROS)	NROS -1 (OROS -1)	NROL (OROL)	NROL -1 (OROL -1)	DDEP	EXR	SD	DY	GROS (OdGSRO)	GROL (OGLRO)	R^2adj FV	R^2adj SN	R^2adj SN & SG	R^2adj LN	R^2adj LN & LG	All
GDP_{t+1}	0.022 (0.520)	0.496 (0.773)	-1.257 (0.475)	**-5.325 (0.062)**	-0.751 (0.796)	-0.059 (0.674)	-0.043 (0.427)	-2.029 (0.169)	0.005 (0.634)	0.002 (0.968)	0.951 (0.862)	-0.003	0.002	-0.015	0.054	0.038	0.021
UN_{t+1}	-0.121 (0.127)	-0.500 (0.847)	2.988 (0.274)	0.685 (0.871)	0.072 (0.987)	**0.455 (0.001)**	-0.066 (0.351)	**6.374 (0.007)**	0.009 (0.687)	-0.025 (0.704)	7.772 (0.405)	0.446	0.475	0.467	0.455	0.456	0.469
$CONS_{t+1}$	0.008 (0.578)	-1.322 (0.200)	-0.377 (0.714)	-1.755 (0.285)	-0.389 (0.821)	**-0.756 (0.000)**	-0.007 (0.785)	**-1.239 (0.069)**	0.006 (0.214)	-0.006 (0.849)	-0.766 (0.852)	0.499	0.515	0.507	0.504	0.498	0.506
INV_{t+1}	0.026 (0.384)	0.059 (0.974)	**-3.361 (0.068)**	**-5.358 (0.069)**	**5.096 (0.095)**	**-0.358 (0.007)**	-0.018 (0.729)	-0.119 (0.929)	-0.006 (0.513)	-0.015 (0.785)	-6.862 (0.168)	0.177	0.127	0.113	0.127	0.163	0.069
Korea	CON	NAMS (OAMS)	NAMS -1 (OAMS -1)	NAML (OAML)	NAML -1 (OAML -1)	DDEP	OEXR	dSD	ODY	GAMS (GSAM)	GAML (GLAM)	R^2adj ALL	R^2adj SN	R^2adj SN & SG	R^2adj LN	R^2adj LN & LG	R^2adj FV
GDP_{t+1}	**0.008 (0.003)**	**2.571 (0.088)**	-1.419 (0.298)	-1.108 (0.819)	-10.28 (0.173)	-0.045 (0.788)	**0.026 (0.089)**	**-0.019 (0.002)**	**-0.013 (0.000)**	**0.001 (0.078)**	1.261 (0.755)	0.350	0.321	0.324	0.334	0.336	0.324
UN_{t+1}	0.003 (0.889)	-12.08 (0.509)	13.605 (0.401)	93.76 (0.139)	31.095 (0.742)	**-0.355 (0.011)**	-0.187 (0.302)	**0.191 (0.007)**	**0.087 (0.023)**	-0.003 (0.644)	**-0.355 (0.011)**	0.196	0.124	0.117	0.235	0.224	0.151
$CONS_{t+1}$	0.004 (0.331)	-0.022 (0.990)	0.083 (0.960)	**-10.83 (0.074)**	2.108 (0.816)	**0.257 (0.099)**	-0.003 (0.862)	**-0.032 (0.000)**	**-0.016 (0.003)**	0.001 (0.335)	6.304 (0.248)	0.453	0.411	0.423	0.438	0.447	0.399
INV_{t+1}	0.0002 (0.963)	1.028 (0.726)	3.181 (0.254)	-8.958 (0.377)	-11.407 (0.448)	0.004 (0.979)	0.0003 (0.993)	**-0.042 (0.001)**	**-0.029 (0.000)**	-0.001 (0.608)	12.93 (0.112)	0.342	0.283	0.286	0.331	0.345	0.278
Dependent	CON	NROS (OROS)	NROL -1 (OROS -1)	NROL (OROL)	NROL -1 (OROL-1)	DDEP	OEXR	dSD	ODY	GROS (OdGSRO)	GROL (OGLRO)	R^2adj FV	R^2adj SN	R^2adj SN & SG	R^2adj LN	R^2adj LN & LG	All
GDP_{t+1}	**0.011 (0.000)**	-0.319 (0.757)	1.386 (0.157)	0.383 (0.744)	2.005 (0.100)	0.122 (0.426)	0.019 (0.135)	**-0.019 (0.000)**	**-0.009 (0.011)**	-0.009 (0.339)	-1.326 (0.163)	0.358	0.333	0.335	0.348	0.357	0.324
UN_{t+1}	0.004 (0.836)	-16.69 (0.225)	5.141 (0.688)	4.906 (0.744)	-18.58 (0.245)	-0.183 (0.186)	-0.185 (0.254)	**0.173 (0.011)**	**0.078 (0.041)**	0.012 (0.925)	12.88 (0.184)	0.159	0.174	0.160	0.169	0.179	0.151
$CONS_{t+1}$	**0.009 (0.014)**	0.582 (0.664)	0.337 (0.767)	**3.644 (0.024)**	0.793 (0.608)	**0.390 (0.006)**	0.004 (0.807)	**-0.026 (0.000)**	**-0.013 (0.019)**	0.018 (0.109)	-1.597 (0.285)	0.436	0.387	0.383	0.437	0.437	0.399
INV_{t+1}	0.005 (0.203)	0.201 (0.930)	1.172 (0.589)	-0.793 (0.765)	2.064 (0.444)	0.134 (0.385)	0.011 (0.704)	**-0.033 (0.006)**	**-0.025 (0.003)**	-0.024 (0.260)	-2.059 (0.332)	0.239	0.258	0.261	0.260	0.259	0.278

Malaysia	CON	NAMS (OAMS)	NAMS -1 (OAMS -1)	NAML (OAML)	NAML -1 (OAML -1)	DDEP	OEXR	dSD	dDY	GAMS (OGSAM)	GAML (OGLAM)	R^2adj ALL	R^2adj SN	R^2adj SN & SG	R^2adj LN	R^2adj LN & LG	R^2adj FV
GDP_{t+1}	**0.012** **(0.000)**	0.244 (0.142)	-0.191 (0.245)	**-4.148** **(0.017)**	**4.697** **(0.008)**	-0.146 (0.239)	**0.159** **(0.008)**	0.011 (0.192)	**-0.091** **(0.000)**	**0.001** **(0.046)**	-13.37 (0.399)	0.294	0.154	0.175	0.264	0.260	0.169
UN_{t+1}	-0.002 (0.839)	-0.801 (0.139)	0.727 (0.173)	**11.533** **(0.039)**	**-10.296** **(0.067)**	-0.177 (0.191)	**-0.348** **(0.069)**	0.0005 (0.985)	**0.244** **(0.001)**	0.001 (0.537)	10.56 (0.834)	0.204	0.164	0.157	0.218	0.205	0.168
$CONS_{t+1}$	**0.013** **(0.012)**	-0.075 (0.761)	0.273 (0.261)	-2.397 (0.346)	0.639 (0.802)	-0.074 (0.595)	0.141 (0.111)	-0.014 (0.264)	0.002 (0.948)	-0.0004 (0.704)	-29.27 (0.226)	-0.024	-0.004	-0.018	-0.009	-0.003	-0.004
INV_{t+1}	0.006 (0.479)	0.297 (0.531)	-0.061 (0.895)	1.081 (0.824)	7.419 (0.133)	-0.194 (0.154)	**0.309** **(0.068)**	0.031 (0.211)	**-0.192** **(0.004)**	0.002 (0.291)	-51.02 (0.247)	0.113	0.092	0.087	0.129	0.133	0.116
Dependent	CON	NROS (OROS)	NROS -1 (OROS -1)	NROL (OROL)	NROL -1 (OROL -1)	DDEP	OEXR	dSD	dDY	GROS (OdGSRO)	GROL (OGLRO)	R^2adj ALL	R^2adj SN	R^2adj SN & SG	R^2adj LN	R^2adj LN & LG	R^2adj FV
GDP_{t+1}	**0.013** **(0.000)**	**-2.732** **(0.093)**	-1.115 (0.469)	**3.646** **(0.021)**	-0.503 (0.752)	-0.210 (0.127)	**0.131** **(0.026)**	0.010 (0.233)	**-0.083** **(0.000)**	-0.031 (0.255)	**-4.403** **(0.017)**	0.312	0.189	0.199	0.219	0.260	0.169
UN_{t+1}	-0.003 (0.795)	5.201 (0.341)	-2.076 (0.691)	-2.884 (0.575)	1.493 (0.780)	-0.199 (0.147)	-0.299 (0.127)	-0.003 (0.915)	**0.236** **(0.002)**	0.095 (0.316)	8.811 (0.151)	0.148	0.152	0.155	0.150	0.164	0.168
$CONS_{t+1}$	**0.013** **(0.012)**	-0.299 (0.906)	-1.779 (0.455)	0.768 (0.739)	1.289 (0.586)	-0.059 (0.684)	0.129 (0.151)	-0.010 (0.417)	0.008 (0.818)	-0.003 (0.942)	-4.199 (0.160)	-0.055	-0.028	-0.046	-0.031	-0.015	-0.004
INV_{t+1}	0.007 (0.378)	-7.383 (0.100)	-3.852 (0.368)	3.829 (0.366)	-3.801 (0.391)	**-0.236** **(0.083)**	0.251 (0.118)	0.036 (0.139)	**-0.189** **(0.003)**	-0.029 (0.701)	-7.552 (0.124)	0.182	0.181	0.171	0.123	0.130	0.116

Philippines	CON	NAMS (OAMS)	NAMS -1 (OAMS -1)	NAML (OAML)	NAML -1 (OAML -1)	DDEP	OdEXR	SD	dDY	GAMS (OGSAM)	GAML (OGLAM)	R^2adj ALL	R^2adj SN	R^2adj SN & SG	R^2adj LN	R^2adj LN & LG	R^2adj FV
GDP_{t+1}	**0.032** **(0.034)**	0.039 (0.175)	**-0.051** **(0.089)**	5.708 (0.782)	3.429 (0.873)	**-0.785** **(0.000)**	0.031 (0.364)	-1.770 (0.147)	-0.006 (0.858)	-0.0001 (0.877)	-16.741 (0.185)	0.560	0.573	0.566	0.553	0.556	0.562
UN_{t+1}	**-0.100** **(0.063)**	-0.057 (0.518)	0.043 (0.629)	-36.19 (0.603)	5.481 (0.939)	-0.309 (0.331)	-0.111 (0.675)	**7.815** **(0.078)**	-0.058 (0.603)	-0.001 (0.787)	15.993 (0.718)	0.124	0.172	0.159	0.172	0.159	0.190
$CONS_{t+1}$	0.023 (0.159)	0.027 (0.384)	-0.032 (0.316)	-8.992 (0.679)	16.413 (0.469)	**-0.861** **(0.000)**	**0.062** **(0.092)**	-0.897 (0.484)	-0.017 (0.605)	-0.004 (0.720)	-14.268 (0.283)	0.339	0.683	0.678	0.678	0.678	0.687
INV_{t+1}	**0.057** **(0.017)**	**0.083** **(0.058)**	**-0.123** **(0.006)**	26.50 (0.403)	-23.47 (0.468)	**-0.439** **(0.001)**	**-0.276** **(0.000)**	**-4.093** **(0.031)**	0.078 (0.127)	0.002 (0.376)	-3.625 (0.857)	0.348	0.376	0.372	0.278	0.266	0.284
Dependent	CON	NROS (OROS)	NROS -1 (OROS -1)	NROL (OROL)	NROL -1 (OROL -1)	DDEP	OdEXR	SD	dDY	GROS (OGSRO)	GROL (OGLRO)	R^2adj ALL	R^2adj SN	R^2adj SN & SG	R^2adj LN	R^2adj LN & LG	R^2adj FV
GDP_{t+1}	**0.039** **(0.032)**	-2.422 (0.228)	2.512 (0.213)	**5.305** **(0.016)**	**-5.464** **(0.019)**	**-0.798** **(0.000)**	0.037 (0.275)	-2.329 (0.102)	-0.015 (0.624)	-1.105 (0.793)	0.033 (0.991)	0.585	0.556	0.549	0.599	0.592	0.562
UN_{t+1}	**-0.141** **(0.037)**	-0.159 (0.981)	-5.614 (0.399)	**-12.198** **(0.078)**	**-12.198** **(0.078)**	-0.322 (0.246)	-0.163 (0.481)	**10.821** **(0.038)**	-0.032 (0.773)	16.146 (0.289)	7.957 (0.486)	0.172	0.171	0.163	0.197	0.187	0.190
$CONS_{t+1}$	**0.032** **(0.077)**	-0.873 (0.655)	1.528 (0.437)	**7.736** **(0.000)**	**-6.573** **(0.005)**	**-0.883** **(0.000)**	**0.058** **(0.083)**	-1.589 (0.253)	-0.032 (0.305)	-1.544 (0.709)	0.972 (0.744)	0.728	0.677	0.672	0.742	0.738	0.687
INV_{t+1}	**0.052** **(0.098)**	-0.608 (0.861)	0.007 (0.998)	5.297 (0.137)	**-8.709** **(0.024)**	**-0.351** **(0.010)**	**-0.249** **(0.000)**	-3.586 (0.139)	0.061 (0.275)	-3.689 (0.618)	-0.195 (0.972)	0.290	0.262	0.255	0.332	0.321	0.284

Dependent	CON	NAMS (OAMS)	NAMS -1 (OAMS -1)	NAML (OAML)	NAML -1 (OAML -1)	DDEP	OEXR	SD	dDY	GAMS (OGSAM)	GAML (OGLAM)	R^2adj ALL	R^2adj SN	R^2adj SN & SG	R^2adj LN	R^2adj LN & LG	R^2adj FV
GDP_{t+1}	**0.023 (0.002)**	0.100 (0.155)	-0.019 (0.783)	-3.557 (0.246)	0.602 (0.859)	0.099 (0.479)	0.037 (0.376)	-0.939 (0.105)	-0.017 (0.421)	0.0002 (0.799)	**-22.71 (0.058)**	0.038	0.019	0.009	0.009	-0.005	0.022
UN_{t+1}	-0.042 (0.200)	-0.241 (0.544)	-0.484 (0.236)	22.60 (0.214)	-2.289 (0.908)	-0.203 (0.166)	**-0.432 (0.076)**	3.652 (0.177)	**0.247 (0.042)**	**-0.009 (0.019)**	30.71 (0.634)	0.150	0.092	0.161	0.044	0.043	0.051
$CONS_{t+1}$	**0.012 (0.019)**	0.013 (0.869)	-0.019 (0.818)	1.864 (0.595)	0.048 (0.989)	**-0.504 (0.000)**	0.061 (0.137)	0.017 (0.967)	**-0.041 (0.040)**	**0.001 (0.041)**	-13.56 (0.225)	0.196	0.157	0.207	0.164	0.178	0.178
INV_{t+1}	**0.031 (0.038)**	-0.201 (0.326)	0.147 (0.484)	-14.36 (0.114)	-10.306 (0.292)	**-0.355 (0.007)**	0.141 (0.214)	-1.689 (0.164)	0.032 (0.562)	-0.0003 (0.865)	39.78 (0.201)	0.116	0.037	0.026	0.139	0.146	0.054
Dependent	CON	NROS (OROS)	NROS -1 (OROS -1)	NROL (OROL)	NROL -1 (OROL -1)	DDEP	OEXR	SD	dDY	GROS (OGSRO)	GROL (OGLRO)	R^2adj ALL	R^2adj SN	R^2adj SN & SG	R^2adj LN	R^2adj LN & LG	R^2adj FV
GDP_{t+1}	**0.025 (0.000)**	1.573 (0.427)	**-3.853 (0.079)**	-0.529 (0.829)	**-5.632 (0.043)**	0.004 (0.977)	0.023 (0.557)	**-0.938 (0.070)**	**-0.037 (0.081)**	2.433 (0.334)	**-7.977 (0.002)**	0.155	0.021	0.004	0.019	0.132	0.022
UN_{t+1}	-0.032 (0.398)	0.504 (0.966)	9.686 (0.462)	-22.195 (0.155)	-21.514 (0.198)	-0.052 (0.741)	-0.373 (0.138)	2.653 (0.381)	0.138 (0.298)	19.13 (0.206)	**26.332 (0.078)**	0.111	0.043	0.037	0.074	0.107	0.051
$CONS_{t+1}$	**0.011 (0.007)**	-0.349 (0.849)	**-6.330 (0.001)**	**6.209 (0.012)**	-2.245 (0.373)	**-0.679 (0.000)**	0.024 (0.485)	0.162 (0.628)	**-0.047 (0.009)**	2.541 (0.142)	**-4.427 (0.033)**	0.362	0.225	0.244	0.262	0.276	0.178
INV_{t+1}	**0.032 (0.049)**	-7.016 (0.229)	10.200 (0.105)	-1.442 (0.841)	-5.775 (0.472)	-0.218 (0.117)	0.108 (0.346)	-1.898 (0.154)	0.043 (0.474)	-8.579 (0.209)	-8.709 (0.215)	0.112	0.082	0.126	0.069	0.087	0.054

Panel B: Summary Table for All markets

All Markets	Financial variable only	National liquidity small	National liquidity & Global liquidity small	National liquidity large	National liquidity & Global liquidity large	ALL	Contributed by Financial variables only	Contributed by National liquidity small	Contributed by National liquidity & Global liquidity small	Contributed by National liquidity large	Contributed by National liquidity & Global liquidity large	Contributed by All
AM → GDP	0.207	0.171	0.171	0.190	0.186	0.182	0.031	0.026	0.026	0.029	0.028	0.027
RO → GDP	0.245	0.183	0.175	0.221	0.242	0.182	0.033	0.024	0.023	0.029	0.032	0.024
AM → UNE	0.26	0.237	0.243	0.244	0.239	0.229	0.029	0.027	0.028	0.028	0.027	0.026
RO → UNE	0.224	0.226	0.219	0.229	0.235	0.236	0.027	0.027	0.027	0.027	0.029	0.029
AM → CON	0.275	0.319	0.327	0.307	0.316	0.308	0.025	0.029	0.029	0.028	0.028	0.028
RO → CON	0.341	0.310	0.307	0.333	0.334	0.308	0.029	0.027	0.026	0.029	0.029	0.026
AM → INV	0.184	0.157	0.159	0.177	0.187	0.152	0.030	0.026	0.026	0.029	0.031	0.025
RO → INV	0.201	0.176	0.193	0.176	0.199	0.152	0.030	0.027	0.029	0.027	0.030	0.023
AM→MACRO (AVERAGES)	0.232	0.221	0.225	0.229	0.232	0.218	0.029	0.027	0.027	0.028	0.029	0.027
RO→MACRO (AVERAGES)	0.253	0.224	0.224	0.239	0.252	0.219	0.029	0.026	0.026	0.028	0.029	0.026

Panel C: Summary Table of Developed markets

Developed Market	Financial variable only	National liquidity small	National liquidity & Global liquidity small	National liquidity large	National liquidity & Global liquidity large	ALL	Contributed by Financial variables only	Contributed by National liquidity small	Contributed by National liquidity & Global liquidity small	Contributed by National liquidity large	Contributed by National liquidity & Global liquidity large	Contributed by All
AM → GDP	0.097	0.074	0.070	0.081	0.074	0.090	0.049	0.038	0.036	0.041	0.038	0.046
RO → GDP	0.143	0.087	0.075	0.126	0.149	0.090	0.053	0.032	0.028	0.047	0.055	0.034
AM → UNE	0.308	0.271	0.285	0.268	0.267	0.255	0.046	0.041	0.043	0.041	0.040	0.038
RO → UNE	0.256	0.259	0.249	0.257	0.265	0.265	0.041	0.042	0.040	0.041	0.043	0.043
AM → CON	0.334	0.309	0.325	0.294	0.305	0.291	0.022	0.016	0.017	0.022	0.024	0.017
RO → CON	0.343	0.303	0.304	0.321	0.320	0.291	0.045	0.040	0.040	0.043	0.042	0.038
AM → INV	0.161	0.119	0.124	0.164	0.180	0.128	0.046	0.034	0.035	0.047	0.051	0.036
RO → INV	0.183	0.153	0.183	0.151	0.186	0.128	0.046	0.039	0.046	0.038	0.047	0.032
AM→MACRO (AVERAGES)	0.225	0.193	0.201	0.202	0.207	0.191	0.041	0.032	0.033	0.038	0.038	0.035
RO→MACRO (AVERAGES)	0.231	0.201	0.203	0.214	0.230	0.193	0.047	0.038	0.039	0.042	0.047	0.037

Panel D: Summary Table of Developing Markets

Developing Market	Financial variable only	National liquidity small	National liquidity & Global liquidity small	National liquidity large	National liquidity & Global liquidity large	ALL	Contributed by Financial variables only	Contributed by National liquidity small	Contributed by National liquidity & Global liquidity small	Contributed by National liquidity large	Contributed by National liquidity & Global liquidity large	Contributed by All
AM → GDP	0.427	0.363	0.370	0.408	0.408	0.365	0.091	0.077	0.079	0.087	0.087	0.078
RO → GDP	0.448	0.372	0.374	0.409	0.426	0.365	0.094	0.078	0.078	0.085	0.089	0.076
AM → UNE	0.164	0.168	0.158	0.195	0.182	0.179	0.078	0.080	0.075	0.093	0.087	0.085
RO → UNE	0.160	0.161	0.159	0.173	0.175	0.179	0.079	0.080	0.079	0.086	0.087	0.089
AM → CON	0.157	0.339	0.330	0.334	0.337	0.341	0.043	0.092	0.089	0.091	0.092	0.093
RO → CON	0.336	0.324	0.313	0.355	0.361	0.341	0.083	0.079	0.077	0.087	0.089	0.084
AM → INV	0.230	0.234	0.229	0.203	0.199	0.200	0.089	0.090	0.088	0.078	0.077	0.077
RO → INV	0.236	0.221	0.213	0.227	0.225	0.200	0.089	0.084	0.080	0.086	0.085	0.075
AM→MACRO (AVERAGES)	0.245	0.276	0.272	0.285	0.282	0.271	0.075	0.085	0.083	0.087	0.085	0.083
RO→MACRO (AVERAGES)	0.295	0.270	0.265	0.291	0.297	0.271	0.086	0.080	0.078	0.086	0.087	0.081

Table 5.7
Granger Causality Tests – Size Portfolios

Table 5.7 shows the results of Granger causality tests between macroeconomic variables (GDP, UN, CONS, and INV) and the illiquidity of small and large firms for our illiquidity proxies. Market illiquidity (LIQ) is captured by the Amihud ratio (AM) and Roll's effective spread (RO). The prefix 'N' in front of each liquidity variable (AM or RO) stands for national and the prefix 'G' stands for global. Global liquidity (GAM and GRO) is created by combining all countries (The US and Japan are included) except the country nominated for the test. The superscripts ^{L} and ^{S} denote illiquidity based on large and small firms. The first column denotes the liquidity variable while the first row denotes the direction of the causality. The null hypotheses are: I) the macro variable does not Granger cause the LIQ variable and II) the LIQ variable does not Granger causes the macro variable. Within cells you can see the χ^2 value and the relevant p value. Panel A shows results for each country while panel B, C, D, E, F, and G summarises results.

Panel A: Results for each country

AUSTRALIA

LIQ	GDP does not →LIQ	LIQ does not → GDP	UN does not →LIQ	LIQ does not → UN	CONS does not →LIQ	LIQ does not → CONS	INV does not →LIQ	LIQ does not → INV
NAM^S	3.945 (0.139)	2.324 (0.313)	0.714 (0.699)	0.496 (0.780)	2.168 (0.338)	**5.307** **(0.070)**	**6.104** **(0.049)**	0.739 (0.691)
NAM^L	1.105 (0.575)	0.693 (0.707)	0.422 (0.809)	0.888 (0.641)	1.002 (0.606)	0.759 (0.684)	**6.384** **(0.041)**	**6.806** **(0.033)**
GAM^S	**14.894** **(0.000)**	1.082 (0.582)	0.151 (0.927)	4.295 (0.117)	1.735 (0.419)	2.136 (0.344)	2.808 (0.245)	**9.106** **(0.010)**
GAM^L	1.256 (0.534)	1.995 (0.369)	4.151 (0.125)	**5.108** **(0.078)**	2.793 (0.247)	2.281 (0.319)	0.191 (0.909)	1.006 (0.605)
NRO^S	**7.544** **(0.023)**	1.250 (0.535)	0.419 (0.811)	0.598 (0.741)	1.739 (0.419)	**5.291** **(0.071)**	4.249 (0.119)	0.393 (0.822)
NRO^L	0.327 (0.849)	3.984 (0.136)	**7.591** **(0.022)**	0.917 (0.632)	1.169 (0.557)	1.345 (0.510)	1.212 (0.545)	4.210 (0.122)
GRO^S	1.870 (0.392)	**5.477** **(0.065)**	0.258 (0.879)	0.323 (0.851)	0.520 (0.771)	1.115 (0.573)	**12.292** **(0.002)**	2.197 (0.333)
GRO^L	0.110 (0.946)	0.275 (0.871)	3.812 (0.149)	0.637 (0.727)	2.719 (0.257)	2.401 (0.301)	0.170 (0.918)	**7.425** **(0.024)**

HONG KONG

LIQ	GDP does not →LIQ	LIQ does not → GDP	UN does not →LIQ	LIQ does not → UN	CONS does not →LIQ	LIQ does not → CONS	INV does not →LIQ	LIQ does not → INV
NAM^S	0.412 (0.814)	0.459 (0.795)	2.365 (0.306)	3.620 (0.164)	0.962 (0.618)	0.812 (0.666)	0.777 (0.678)	0.357 (0.836)
NAM^L	0.594 (0.723)	0.233 (0.890)	1.675 (0.433)	1.922 (0.382)	0.273 (0.872)	1.211 (0.546)	0.808 (0.668)	0.381 (0.826)
GAM^S	0.495 (0.781)	3.421 (0.181)	**5.204** **(0.074)**	0.051 (0.975)	0.484 (0.785)	3.621 (0.163)	2.909 (0.233)	1.997 (0.368)
GAM^L	3.303 (0.219)	**13.796** **(0.001)**	4.032 (0.133)	0.574 (0.750)	4.492 (0.106)	**5.221** **(0.073)**	3.163 (0.206)	**7.467** **(0.024)**
NRO^S	0.802 (0.669)	4.061 (0.131)	3.171 (0.205)	2.719 (0.257)	0.946 (0.623)	1.740 (0.419)	0.394 (0.821)	**8.303** **(0.016)**
NRO^L	**5.500** **(0.064)**	2.469 (0.291)	0.149 (0.928)	0.058 (0.972)	1.302 (0.521)	1.634 (0.442)	0.331 (0.847)	**6.349** **(0.042)**
GRO^S	0.249 (0.883)	2.112 (0.348)	2.263 (0.322)	0.157 (0.924)	0.668 (0.716)	0.714 (0.699)	3.637 (0.162)	0.719 (0.698)
GRO^L	3.703 (0.157)	**15.545** **(0.000)**	1.581 (0.453)	**9.440** **(0.009)**	1.876 (0.391)	**8.304** **(0.016)**	**6.468** **(0.039)**	**9.239** **(0.009)**

KOREA									MALAYSIA								
LIQ	GDP does not →LIQ	LIQ does not → GDP	UN does not →LIQ	LIQ does not → UN	CONS does not →LIQ	LIQ does not → CONS	INV does not →LIQ	LIQ does not → INV	LIQ	GDP does not →LIQ	LIQ does not → GDP	UN does not →LIQ	LIQ does not → UN	CONS does not →LIQ	LIQ does not → CONS	INV does not →LIQ	LIQ does not → INV
NAM^S	**23.506** **(0.000)**	0.965 (0.617)	**6.836** **(0.033)**	0.428 (0.807)	**40.981** **(0.000)**	1.647 (0.439)	**12.189** **(0.002)**	0.350 (0.839)	NAM^S	4.201 (0.122)	0.625 (0.732)	3.569 (0.168)	0.889 (0.641)	3.850 (0.146)	2.330 (0.312)	3.624 (0.163)	0.663 (0.718)
NAM^L	**22.127** **(0.000)**	**4.827** **(0.089)**	3.096 (0.213)	**19.948** **(0.000)**	**32.006** **(0.000)**	**10.667** **(0.005)**	**20.923** **(0.000)**	4.227 (0.121)	NAM^L	0.334 (0.846)	**4.804** **(0.091)**	2.952 (0.228)	2.956 (0.228)	1.891 (0.388)	0.492 (0.782)	1.842 (0.398)	0.631 (0.729)
GAM^S	**10.857** **(0.004)**	4.534 (0.104)	4.312 (0.116)	**5.021** **(0.081)**	**9.615** **(0.008)**	2.497 (0.287)	**7.795** **(0.020)**	2.624 (0.269)	GAM^S	0.247 (0.884)	3.860 (0.145)	1.189 (0.552)	**11.914** **(0.002)**	0.414 (0.813)	0.095 (0.954)	1.738 (0.419)	0.072 (0.965)
GAM^L	1.064 (0.587)	1.043 (0.594)	1.158 (0.560)	**6.027** **(0.005)**	0.635 (0.728)	1.767 (0.413)	1.559 (0.458)	0.676 (0.713)	GAM^L	0.041 (0.979)	**12.959** **(0.001)**	2.009 (0.366)	2.230 (0.328)	**5.217** **(0.074)**	**4.855** **(0.088)**	3.833 (0.147)	0.2997 (0.223)
NRO^S	0.142 (0.931)	0.873 (0.646)	2.725 (0.256)	2.571 (0.276)	0.959 (0.619)	0.135 (0.935)	0.581 (0.748)	0.256 (0.879)	NRO^S	4.366 (0.113)	4.511 (0.105)	0.767 (0.681)	0.229 (0.892)	2.744 (0.254)	1.126 (0.569)	3.311 (0.191)	**7.715** **(0.021)**
NRO^L	**8.921** **(0.011)**	3.727 (0.155)	**6.859** **(0.032)**	1.821 (0.402)	4.175 (0.124)	**5.815** **(0.054)**	3.305 (0.191)	2.276 (0.320)	NRO^L	**13.099** **(0.001)**	1.683 (0.431)	**8.135** **(0.017)**	1.823 (0.402)	0.446 (0.800)	0.125 (0.939)	**9.715** **(0.008)**	2.610 (0.271)
GRO^S	2.028 (0.363)	0.581 (0.748)	0.786 (0.675)	0.182 (0.913)	0.474 (0.789)	**5.307** **(0.070)**	1.382 (0.501)	0.671 (0.715)	GRO^S	**5.920** **(0.052)**	2.386 (0.303)	1.761 (0.414)	3.878 (0.144)	1.509 (0.470)	0.317 (0.853)	**12.794** **(0.002)**	**8.287** **(0.016)**
GRO^L	2.222 (0.329)	2.542 (0.280)	2.647 (0.266)	2.147 (0.342)	**5.991** **(0.050)**	2.157 (0.340)	4.556 (0.102)	2.886 (0.236)	GRO^L	3.139 (0.208)	**13.652** **(0.001)**	2.748 (0.253)	**6.697** **(0.035)**	3.997 (0.135)	**6.154** **(0.046)**	0.942 (0.624)	**5.844** **(0.054)**

PHILIPPINES								
LIQ	GDP does not →LIQ	LIQ does not → GDP	UN does not →LIQ	LIQ does not → UN	CONS does not →LIQ	LIQ does not → CONS	INV does not →LIQ	LIQ does not → INV
NAM^S	1.068 (0.586)	1.843 (0.398)	2.224 (0.329)	0.113 (0.945)	1.326 (0.515)	1.663 (0.435)	0.742 (0.689)	2.255 (0.324)
NAM^L	0.184 (0.912)	0.919 (0.631)	0.478 (0.787)	0.706 (0.702)	0.476 (0.788)	0.407 (0.816)	0.169 (0.918)	0.560 (0.756)
GAM^S	0.369 (0.831)	0.152 (0.927)	**7.577 (0.023)**	2.525 (0.283)	0.139 (0.933)	0.328 (0.848)	**5.039 (0.080)**	0.051 (0.975)
GAM^L	2.418 (0.298)	2.989 (0.224)	2.964 (0.227)	3.054 (0.217)	2.589 (0.274)	1.181 (0.554)	3.389 (0.184)	3.658 (0.160)
NRO^S	0.574 (0.751)	1.348 (0.509)	4.299 (0.116)	0.553 (0.758)	0.512 (0.774)	0.170 (0.918)	1.481 (0.477)	2.908 (0.234)
NRO^L	**6.166 (0.046)**	**7.339 (0.025)**	**9.640 (0.008)**	0.482 (0.786)	**9.828 (0.007)**	**9.204 (0.010)**	1.382 (0.501)	**9.077 (0.011)**
GRO^S	0.357 (0.836)	2.477 (0.289)	0.928 (0.629)	0.363 (0.834)	0.462 (0.794)	1.005 (0.605)	4.536 (0.103)	**5.982 (0.050)**
GRO^L	1.295 (0.523)	1.155 (0.561)	1.260 (0.532)	1.705 (0.426)	0.876 (0.645)	0.369 (0.831)	3.000 (0.211)	**12.961 (0.001)**

SINGAPORE								
LIQ	GDP does not →LIQ	LIQ does not → GDP	UN does not →LIQ	LIQ does not → UN	CONS does not →LIQ	LIQ does not → CONS	INV does not →LIQ	LIQ does not → INV
NAM^S	**5.182 (0.075)**	2.562 (0.278)	**4.682 (0.096)**	3.551 (0.169)	1.083 (0.582)	1.823 (0.402)	**7.954 (0.019)**	1.268 (0.530)
NAM^L	0.559 (0.756)	**4.983 (0.083)**	0.739 (0.691)	2.084 (0.353)	0.407 (0.816)	1.410 (0.494)	0.955 (0.620)	**7.189 (0.027)**
GAM^S	0.680 (0.712)	4.571 (0.102)	**7.621 (0.022)**	4.051 (0.132)	0.424 (0.809)	4.441 (0.108)	0.708 (0.702)	0.160 (0.923)
GAM^L	1.501 (0.472)	**10.169 (0.006)**	1.034 (0.596)	0.958 (0.619)	1.389 (0.499)	**8.977 (0.011)**	**4.733 (0.094)**	1.906 (0.385)
NRO^S	2.251 (0.324)	4.361 (0.113)	1.478 (0.477)	0.572 (0.751)	**4.951 (0.084)**	**6.703 (0.035)**	**7.674 (0.021)**	4.180 (0.124)
NRO^L	**11.653 (0.003)**	1.133 (0.567)	**5.423 (0.066)**	**6.732 (0.034)**	**4.772 (0.092)**	**9.077 (0.011)**	3.952 (0.139)	0.981 (0.612)
GRO^S	4.043 (0.132)	0.899 (0.638)	0.092 (0.955)	3.759 (0.153)	**5.833 (0.054)**	**5.631 (0.059)**	0.826 (0.661)	1.578 (0.454)
GRO^L	0.804 (0.669)	**14.109 (0.000)**	1.188 (0.552)	**6.806 (0.033)**	2.526 (0.283)	**8.303 (0.016)**	3.392 (0.183)	2.262 (0.323)

Panel B: Summary Table of All Markets

All Markets	Number of times H_0 (LIQ does not → MACRO) is rejected, split between large and small	National/global	Number of times H_0 (LIQ does not → MACRO) is rejected, split between national and global	Number of times H_0 (LIQ does not → MACRO) is rejected, split between AM & RO
Small	13/96 (13.5%)	National	5/48 (10.4%)	AM: 1/24 (4.2%)
				RO: 4/24 (16.7%)
		global	8/48 (16.7%)	AM: 3/24 (12.5%)
				RO: 5/24 (20.8%)
Large	36/96 (37.5%)	National	14/48 (29.2%)	AM: 7/24 (29.2%)
				RO: 7/24 (29.2%)
		global	22/48 (45.8%)	AM: 9/24 (37.5%)
				RO: 13/24 (54.2%)

Panel C: Summary Table of Developed Markets

Developed Market	Number of times H_0 (LIQ does not → MACRO) is rejected, split between large and small	National/Global	Number of times H_0 (LIQ does not → MACRO) is rejected, split between national and global	Number of times H_0 (LIQ does not → MACRO) is rejected, split between AM & RO
Small	9/64 (14.1%)	National	4/32 (12.5%)	AM: 1/24 (4.2%)
				RO: 3/24 (12.5%)
		Global	5/32 (15.6%)	AM: 2/24 (8.3%)
				RO: 3/24 (12.5%)
Large	25/64 (39.1%)	National	10/32 (31.2%)	AM: 6/24 (25%)
				RO: 4/24 (16.7%)
		Global	16/32 (50%)	AM: 7/24 (29.2%)
				RO: 8/24 (33.3%)

Panel D: Summary table of Developing Markets

Developing Market	Number of times H_0 (LIQ does not → MACRO) is rejected, split between large and small	National/Global	Number of times H_0 (LIQ does not → MACRO) is rejected, split between national and global	Number of times H_0 (LIQ does not → MACRO) is rejected, split between AM & RO
Small	4/32 (12.5%)	National	1/16 (6.2%)	AM: 0/8 (0%)
				RO: 1/8 (12.5%)
		Global	3/16 (18.7%)	AM: 1/8 (12.5%)
				RO: 2/8 (25%)
Large	11/32 (34.4%)	National	4/16 (25%)	AM: 1/8 (12.5%)
				RO: 3/8 (37.5%)
		Global	7/16 (43.7%)	AM: 2/8 (25%)
				RO: 5/8 (62.5%)

Panel E: Summary Table of All Markets

All Markets	Number of times H_0 (MACRO does not → LIQ) is rejected, split between large and small	National/global	Number of times H_0 (MACRO does not → LIQ) is rejected, split between national and global	Number of times H_0 (MACRO does not → LIQ) is rejected, split between AM & RO
Small	23/96 (23.9 %)	National	11/48 (22.9 %)	AM: 8/24 (33.3%)
				RO: 3/24 (12.5%)
		global	12/48 (25 %)	AM: 8/24 (33.3%)
				RO: 4/24 (16.6%)
Large	21/96 (21.8 %)	National	17/48 (35.4 %)	AM: 4/24 (16.6%)
				RO: 13/24 (54.1%)
		global	4/48 (8.3%)	AM: 2/24 (8.3%)
				RO: 2/24 (8.3%)

Panel F: Summary Table of Developed Markets

Developed Market	Number of times H_0 (MACRO does not → LIQ) is rejected, split between large and small	National/Global	Number of times H_0 (MACRO does not → LIQ) is rejected, split between local and global	Number of times H_0 (MACRO does not → LIQ) is rejected, split between AM & RO
Small	19/64 (29.6%)	National	11/32 (34.3%)	AM: 8/24 (33.3%)
				RO: 3/24 (12.5%)
		Global	8/32 (25%)	AM: 6/24 (25%)
				RO: 2/24 (8.3%)
Large	14/64 (21.8%)	National	11/32 (34.3%)	AM: 4/24 (16.7%)
				RO: 7/24 (29.1%)
		Global	3/32 (9.4%)	AM: 1/24 (4.1%)
				RO: 2/24 (8.3%)

Panel G: Summary table of Developing Markets

Developing Market	Number of times H_0 (MACRO does not → LIQ) is rejected, split between large and small	National/Global	Number of times H_0 (MACRO does not → LIQ) is rejected, split between local and global	Number of times H_0 (MACRO does not → LIQ) is rejected, split between AM & RO
Small	4/32 (12.5%)	National	0/16 (0 %)	AM: 0/8 (0%)
				RO: 0/8 (0%)
		Global	4/16 (25 %)	AM: 2/8 (25%)
				RO: 2/8 (25%)
Large	7/32 (21.8%)	National	6/16 (37.5%)	AM: 0/8 (0%)
				RO: 6/8 (75%)
		Global	1/16 (6.2 %)	AM: 1/8 (12.5%)
				RO: 0/8 (0%)

CHAPTER 6: CONCLUSION

At the beginning of this thesis, it was argued that, while it has been long understood that liquidity is an essential element for the functioning of financial markets, not enough attention has been paid to the less researched issues in the market microstructure literature. The thesis investigated some of these issues, namely, the liquidity volatility spillover effect, multidimensional characteristics of liquidity, and the role of liquidity in economic performance.

The first chapter identified a gap in the financial theory with respect to both systematic liquidity and market contagion. Since systematic liquidity, which is defined as the co-movement of liquidity across stocks, sectors and markets, can be observed, the commonality in liquidity can be a potential channel through which the liquidity risks spill over worldwide, especially during market downturns. There is a large body of literature on spillover effect, but almost all of it focuses on the price and return volatility spillover effect. Therefore, this thesis investigated liquidity volatility spillover effect among international stock markets. Chapter Three confirmed the existence of liquidity volatility spillover effects. Specifically, significant spillover effects were found between the UK-US group, the UK-China group and the UK-Korea group. The evidence suggests that the risk associated with market making between countries, which are in different continents, is strongly correlated. The conventional market contagion theory in the literature says that it is a more prominent phenomenon as the global economy has grown and economies within certain geographic regions have become more correlated with one another. This study supports the theory of contagion by providing the evidence of significant spillover effects between the UK and selected Asian countries. More importantly, it is the evidence that extends the contagion phenomenon within certain geographic regions to the global phenomenon. Thus it confirmed the existence of commonality in liquidity in global level.

The empirical study had some limitations which stemmed from the unavailability of data and non-synchronised trading hours. Although, the period of the financial crisis (2007-2009) was included in our sample, the study could not test the liquidity volatility spillover effect during the normal and crisis periods separately, due to the small sample size which could induce misbehaviour of the GARCH-M model.

Chapter Four pointed out the potential contentions associated with the multi-dimensional characteristics of liquidity. Since liquidity is not a simple concept to explore and not directly observable, various liquidity measures proposed in the literature behave in different manners over time. Thus, this chapter argued that it was crucial to analyse markets using a type of liquidity measure which would capture as many facets of liquidity as possible, because differences in dimensions of proxy could lead to different conclusions. It estimated an across-measure, which was obtained by extracting the common factors across a number of different measures of liquidity, testing if there was commonality in liquidity in the UK market. Results were consistent with the evidences from the US market (K&S, 2008). The study found that there was a strong commonality across assets for each individual measure of liquidity. The relation between the within-measure and across-measure was statistically significant, and these measures were contemporaneously correlated with returns. However, this study obtained weaker evidence regarding the pricing of liquidity. For instance, while the CAPM-beta and the across-measure are statistically significant in all models, the coefficient of across-measure becomes statistically insignificant after controlling for the Fama-French four factors. This implies that the adjustment of liquidity risk in the UK market is faster than the US market. In other words, the UK stock market has a shorter life span of liquidity risk compared to the US market. This weaker evidence regarding the pricing of liquidity for the UK market could have been a result of the weaker persistence of liquidity compared to the US market and smaller sample size.

Chapter Five, which included the last empirical study, propounded the view that liquidity variables have some predictability for macroeconomic performance, but this predictability is country and variable specific. It extended the ongoing debate regarding the relationship between market liquidity and macroeconomic variables by investigating the developed and developing Asia-Pacific economies. This is the first empirical study investigating the effect of national and global stock market liquidity on macroeconomic variables, such as GDP, unemployment, consumption and investment, for Australia, Hong Kong, Korea, Philippines, Singapore and Malaysia.

Results show that liquidity variables are able to predict macroeconomic variables even after controlling for financial variables, but these are not consistent over our six selected countries. The contribution made by global liquidity to the regression model is always higher than the contribution made by national liquidity to the countries. Regrouping our six countries as developed and developing markets following the FTSE country classification, the study obtained important evidence that confirm the varying impact of liquidity on economic performance of the countries. For instance, global liquidity has a stronger impact on macroeconomic variables than national liquidity, while the macroeconomic variables have a stronger impact on national liquidity than global liquidity. Also, changes in macroeconomic variables for the developed markets have a stronger impact on small national firms' liquidity, while changes in macroeconomic variables for developing markets have a stronger impact on large national firms' liquidity.

This thesis can be summarised as follows. Firstly, this thesis confirmed that liquidity is such an important risk factor which is weakly priced in the UK market. Also it found the existence of commonality in liquidity across stocks. Furthermore, based on this given evidence of commonality in liquidity in the UK, the study extended to the international liquidity volatility spillover effect between the UK and Asian markets and found that there are significant liquidity spillover effects between the UK and Asian markets. These findings suggest that the uncertainty associated with the adjustment for market making in the international stock market is strongly correlated and spills over from one market to the other market. In other words, this thesis confirmed the existence of commonality in liquidity in the global level.

Secondly, as the importance of multi-dimensional characteristics of liquidity proxy is emphasized, this thesis clearly showed that various liquidity proxies behave in different manor that caused a mixed result through this thesis. Thus, it is very crucial to analyse markets using a type of liquidity measure which captures as many facets of liquidity as possible in order to reconcile the different relations observed.

Thirdly, this study argued that there are variations in country specifics which are important factors to be taken into account for analysing international stock markets, especially, in the relationship between liquidity and economic conditions. For instance, a country has the priory sector which creates the biggest contribution to the economic growth and it differs to each country. This different preference in an economy could create different market characteristics such as the economic structure, the trading mechanism, the type of investors, market efficiency in general, and the strength of regulations. Thus, the market reaction to the risk must be different for each country and these country specifications are reflected in the inconsistent result over countries. The study confirmed that the impact of liquidity risk on economic conditions is varying over countries (G8 countries and 6 Asian countries). Contrary to the evidence from the literature, this study found that global liquidity is more important factor in the 6 Asian countries while G&G (2011) found national liquidity is more important than global liquidity in G7 countries. Selected Asian countries are more sensitive to the external shocks than internal shocks while G7 economies show that its own liquidity risk is more important than the external liquidity risk. Also, the economic development of these Asian countries has an impact on its own market but it does not have any impact on the global liquidity level.

However, there are some issues that have not been covered in this thesis. For instance, which country specific factors are important and how these factors are related to the interdependency of the global market. If these country specifics are important factor, further investigation is necessary to elaborate whether these factors can alter the result in the international market relationship. Since generalized investment strategy and regulations do not perfectly fit for all countries, it needs a modification with these factors in analysing international market relationship. Therefore, it could provide a clearer and explicit guidance with potentially important country specific factors for market participants such as institutional investors, policy makers and market makers.

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APPENDIX

Table A1: Orthogonalized variables

This table presents the summary of orthogonalizaed independent variables. the independent variables are volatility (SD), dividend yield (DY), excess market returns (EXR), the Amihud measure (AM), Roll measure (RO), national Amihud (NAM), global Amihud (GAM), national RO (NRO), global RO (GRO). This orthogonalization process is required to avoid multicollinearity between independent variables. For instance, if independent variables such as volatility and dividend yield are correlated then it regresses volatility on dividend yield and then save the residual from the estimation. The volatility is replaced by the saved residual as the orthogonalized volatility for the main test. The variable start with "O" indicates that the variable is orthogonalized and variables without "O" in front of the name indicate the original variable. Global liquidity is created by combining all countries (the US and Japan are included) except the country nominated for the test.

	Amihud (AM)	Roll (RO)	Global Amihud (GAM)	Global Roll (GRO)	Volatility (SD)	Dividend yield (DY)	Excess market return (EXR)
Hong Kong	OAM	ORO	OGAM	OGRO	SD	DY	EXR
Korea	OAM	RO	OGAM	OGRO	SD	ODY	OEXR
Australia	OAM	ORO	GAM	OGRO	SD	DY	OEXR
Malaysia	OAM	ORO	OGAM	OGRO	SD	DY	OEXR
Philippines	OAM	ORO	OGAM	OGRO	SD	DY	OEXR
Singapore	OAM	ORO	GAM	OGRO	SD	DY	OEXR

Table A2: The Dumitrescu and Hurlin Causality Test.

This table shows the Dumitrescu and Hurlin (2012) causality test between quarterly macroeconomic variables (GDP, INV, CONS, and UN) and all liquidity variables. A pooled time series data set is used over 6 countries. Firstly, it tests the null hypothesis that our liquidity variable does not cause the macroeconomic variable in question and then it tests the null hypothesis that macroeconomic variable does not cause the liquidity variable in question.

Dumitrescu-Hurlin Causality Tests											
The National Amihud			The National ROLL			The Global Amihud			The Global ROLL		
	Lags:2	Lags:4		Lags:2	Lags:4		Lags:2	Lags:4		Lags:2	Lags:4
GDP →AM	**8.6671** **(0.0000)**	**11.6742** **(0.0000)**	GDP → RO	0.9602 (0.2046)	2.7761 (0.2781)	GDP →AM	2.4684 (0.6438)	5.7099 (0.2153)	GDP → RO	1.6561 (0.6385)	3.9254 (0.8617)
AM →GDP	3.1596 (0.2093)	4.0863 (0.9626)	RO → GDP	2.1935 (0.8833)	4.8632 (0.5697)	AM →GDP	1.7373 (0.7064)	2.6154 (0.2256)	RO → GDP	1.5591 (0.5611)	3.2044 (0.4561)
UNE →AM	1.0304 (0.2349)	3.6813 (0.7132)	UNE → RO	2.9827 (0.2925)	4.0104 (0.9149)	UNE →AM	2.3034 (0.7848)	3.8552 (0.8182)	UNE → RO	1.4426 (0.4747)	3.4080 (0.5592)
AM →UNE	**1.3880** **(0.0077)**	5.7353 (0.2080)	RO → UNE	1.4190 (0.4581)	5.1202 (0.4401)	AM →UNE	**3.5667** **(0.0849)**	4.1049 (0.9744)	RO → UNE	2.0888 (0.9787)	4.2173 (0.9546)
CON →AM	**9.1406** **(0.0000)**	**10.4540** **(0.0000)**	CON → RO	2.1644 (0.9096)	4.1177 (0.9825)	CON →AM	2.0986 (0.9698)	4.0337 (0.9295)	CON → RO	0.5255 (0.0772)	2.2876 (0.1412)
AM →CON	2.4696 (0.6429)	3.4361 (0.5743)	RO → CON	1.2922 (0.3748)	4.0859 (0.9624)	AM →CON	1.1730 (0.3057)	2.8772 (0.3152)	RO → CON	1.3616 (0.4192)	2.9388 (0.3393)
INV →AM	0.7824 (0.1409)	3.5185 (0.6195)	INV → RO	0.8601 (0.1665)	3.3942 (0.5518)	INV →AM	1.2924 (0.3749)	3.0590 (0.3895)	INV → RO	1.3551 (0.4149)	2.6972 (0.2514)
AM →INV	**4.1585** **(0.0163)**	**6.4609** **(0.0667)**	RO → INV	**4.2307** **(0.0130)**	**7.7017** **(0.0049)**	AM →INV	**4.4680** **(0.0030)**	6.2073 (0.1025)	RO → INV	0.9466 (0.1991)	3.6470 (0.6930)

Dumitrescu-Hurlin Causality Tests for Developed Markets											
The National Amihud			The National ROLL			The Global Amihud			The Global ROLL		
	Lags:2	Lags:4		Lags:2	Lags:4		Lags:2	Lags:4		Lags:2	Lags:4
GDP →AM	2.9747 (0.3943)	4.1986 (0.9726)	GDP → RO	1.1346 (0.3831)	2.0419 (0.1737)	GDP →AM	0.9628 (0.3015)	4.5245 (0.8063)	GDP → RO	2.4088 (0.7477)	5.4843 (0.3866)
AM →GDP	2.0573 (0.9939)	3.4129 (0.6357)	RO → GDP	3.0233 (0.3695)	6.6641 (0.1034)	AM →GDP	2.2353 (0.8736)	2.5969 (0.3166)	RO → GDP	2.0319 (0.9749)	3.8970 (0.8724)
UNE →AM	0.3559 (0.1092)	4.0713 (0.9618)	UNE → RO	3.3521 (0.2280)	4.2675 (0.9371)	UNE →AM	2.6490 (0.5846)	4.9977 (0.5815)	UNE → RO	2.0162 (0.9631)	4.5468 (0.7952)
AM →UNE	2.8400 (0.4680)	4.3177 (0.9113)	RO → UNE	1.5826 (0.6509)	6.6051 (0.1117)	AM →UNE	**5.1631** **(0.0037)**	5.8734 (0.2638)	RO → UNE	3.0787 (0.3424)	5.9105 (0.2537)
CON →AM	2.1887 (0.9081)	3.6187 (0.7334)	CON → RO	3.1483 (0.3103)	4.4341 (0.8519)	CON →AM	1.5616 (0.6368)	1.8537 (0.1383)	CON → RO	0.7210 (0.2077)	2.6411 (0.3307)
AM →CON	1.6649 (0.7074)	3.3992 (0.6294)	RO → CON	1.4411 (0.5585)	5.2906 (0.4589)	AM →CON	1.6223 (0.6779)	3.3367 (0.6010)	RO → CON	1.7546 (0.7708)	3.1861 (0.5350)
INV →AM	0.8308 (0.2473)	4.0961 (0.9746)	INV → RO	1.2445 (0.4417)	3.5086 (0.6805)	INV →AM	0.6927 (0.1983)	2.6450 (0.3319)	INV → RO	1.0713 (0.3515)	2.7520 (0.3675)
AM →INV	**4.3042** **(0.0359)**	6.3506 (0.1539)	RO → INV	**4.1260** **(0.0535)**	**8.8430** **(0.0024)**	AM →INV	**6.0727** **(0.0002)**	6.0571 (0.2164)	RO → INV	1.2728 (0.4576)	4.6596 (0.7395)

Dumitrescu-Hurlin Causality Tests for Developing Markets											
The National Amihud			The National ROLL			The Global Amihud			The Global ROLL		
	Lags:2	Lags:4		Lags:2	Lags:4		Lags:2	Lags:4		Lags:2	Lags:4
GDP →AM	**20.0517** **(0.0000)**	**26.6252** **(0.0000)**	GDP → RO	0.6114 (0.3353)	4.2444 (0.9639)	GDP→GAM	**5.4797** **(0.0237)**	**8.0806** **(0.0719)**	GDP → GRO	0.1508 (0.2046)	0.8077 (0.1270)
AM →GDP	**5.3642** **(0.0288)**	5.4331 (0.5560)	RO → GDP	0.5339 (0.3102)	1.2613 (0.1872)	GAM→GDP	0.7413 (0.3803)	2.6523 (0.4948)	GRO → GDP	0.6134 (0.3360)	1.8192 (0.2875)
UNE →AM	2.3793 (0.8353)	2.9012 (0.5694)	UNE → RO	2.2439 (0.9059)	3.4963 (0.7666)	UNE→GAM	1.6123 (0.7639)	1.5700 (0.2389)	UNE → GRO	0.2954 (0.2409)	1.1305 (0.1680)
AM →UNE	**7.4839** **(0.0003)**	**8.5704** **(0.0430)**	RO → UNE	1.0917 (0.5188)	2.1505 (0.3617)	GAM→UNE	0.3739 (0.2624)	0.5680 (0.1019)	GRO → UNE	0.1089 (0.1948)	0.8311 (0.1296)
CON →AM	**23.0445** **(0.0000)**	**24.1246** **(0.0000)**	CON → RO	0.1967 (0.2156)	3.4849 (0.7626)	CON→GAM	3.1725 (0.4633)	**8.3937** **(0.0521)**	CON → GRO	0.1344 (0.2007)	1.5805 (0.2409)
AM →CON	4.0788 (0.1822)	3.5099 (0.7713)	RO → CON	0.9945 (0.4779)	1.6764 (0.2589)	GAM→CON	0.2744 (0.2353)	1.9581 (0.3172)	GRO → CON	0.5756 (0.3235)	2.4442 (0.4366)
INV →AM	0.6858 (0.3606)	2.3633 (0.4151)	INV → RO	0.0912 (0.1908)	3.1653 (0.6540)	INV →GAM	2.4916 (0.7777)	3.8869 (0.9059)	INV → GRO	1.9229 (0.9247)	2.5876 (0.4763)
AM →INV	3.8672 (0.2326)	6.6816 (0.2462)	RO → INV	4.4402 (0.1156)	5.4192 (0.5603)	GAM →INV	1.7987 (0.8597)	6.5077 (0.2801)	GRO → INV	0.2943 (0.2406)	1.6218 (0.2485)